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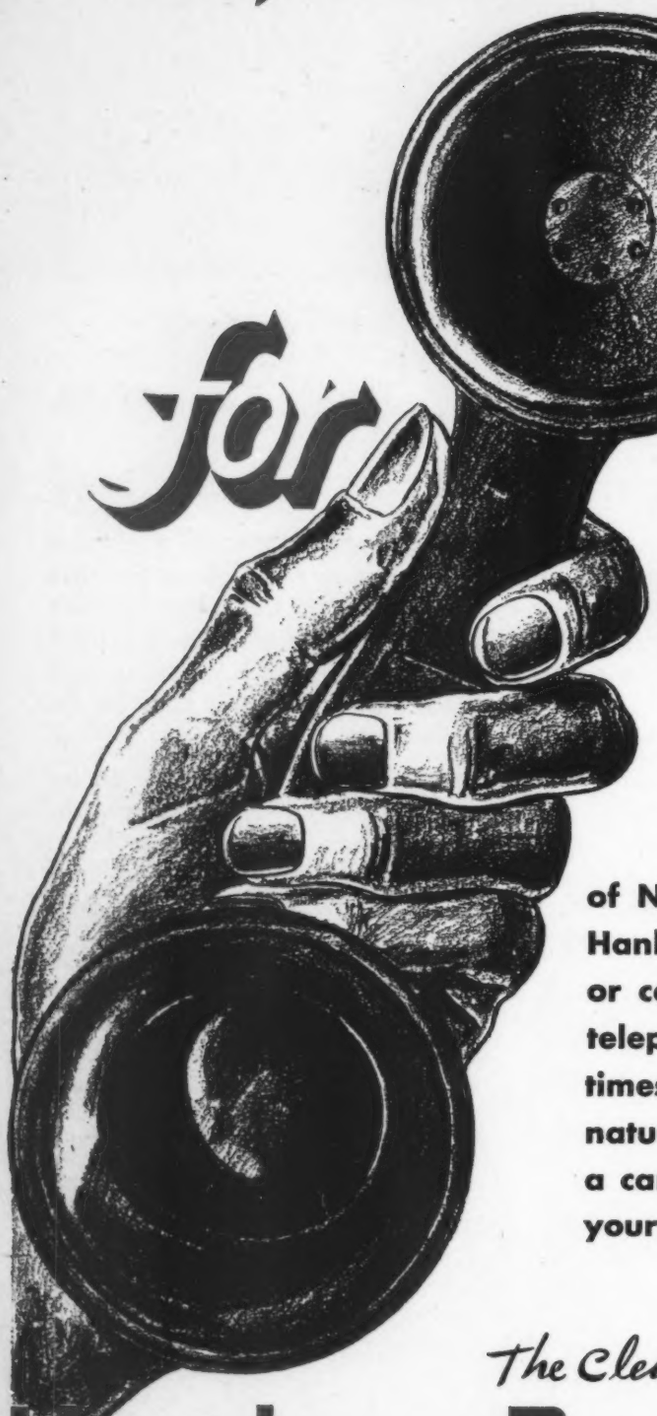

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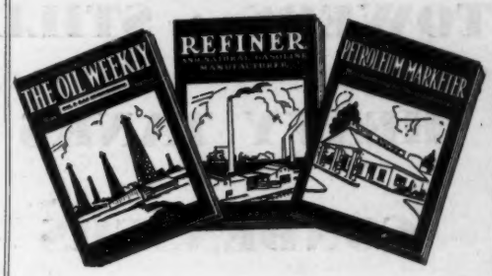

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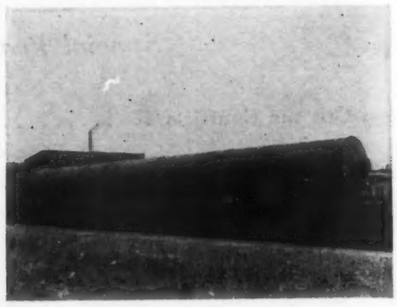

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Iron Out the Conflicts

IT is regrettable that the refining division of the petroleum industry must present a divided front at Washington when the administration is looking for a code of fair competition for oil. One code has been prepared in Chicago, where refining was made a part of the deliberations of marketing. This code is due to go down with the backing of a major part of the industry and a division of opinion on just one point, the lease and agency method of service station control.

Texas independent refiners will present another code at Washington. No group should be criticized for formulating its code. The National Industrial Recovery Act provides for that and the administrator under this new law is asking for codes. He is impatient because industries are inclined to delay. There is little doubt, however, that any industry will fare better by taking only one code to Washington.

The impatience of the administration makes difference of opinion a hazardous game at Washington. When divisions within an industry threaten to extend a hearing over a long period, the disposition at Washington is not going to be for a full discussion and ample time for a decision. The order of the day in Washington is to get to work under the new regulations and let differences be settled later.

On that account the petroleum industry may find itself put to work under a temporary code with instructions to come back later to discuss its minor differences. It is to be hoped that such will not result but those headed for Washington with thick briefs and long arguments in mind can well reflect on such an outcome.

The National Industrial Recovery Act became law for the simple reason that industry failed. Exponents of business enterprise may not like such an estimate but it is the truth. Had business as conducted in the United States been able to keep up proper levels of employment, pay taxes and provide profit on investment, there would have been no law such as that under which industry must now operate.

No small part of the cause for this failure was the bickering between factions within an industry. The oil industry has had its warring factions for so long that the weapons and wanderings of each side are common knowledge. The public has grown tired of listening. If these old differences of opinion are not to be carried to Washington instead of to conventions and conferences, authorities in the national capital will be tired before any words are spoken.

In such an event a code that neither side favors may be the one under which petroleum sets forth to draw its hand in the new deal.

Having failed as a private venture, business must accept guidance from officials selected for providing guidance. The question finally gets down to this—can men not wedded to any faction of an industry become better guides than those already engaged in the industry? If men can improve their vision under such conditions, there is some hope in the recovery act.

But industry in general should get rid of some impressions it holds about this national law. Evidently men are convinced that this new law is an assurance of profit to business. It offers no such assurance. It does offer opportunity to change the methods of conducting business and these changes may bring profit. But business will still demand effort and thought if it is to be profitable.

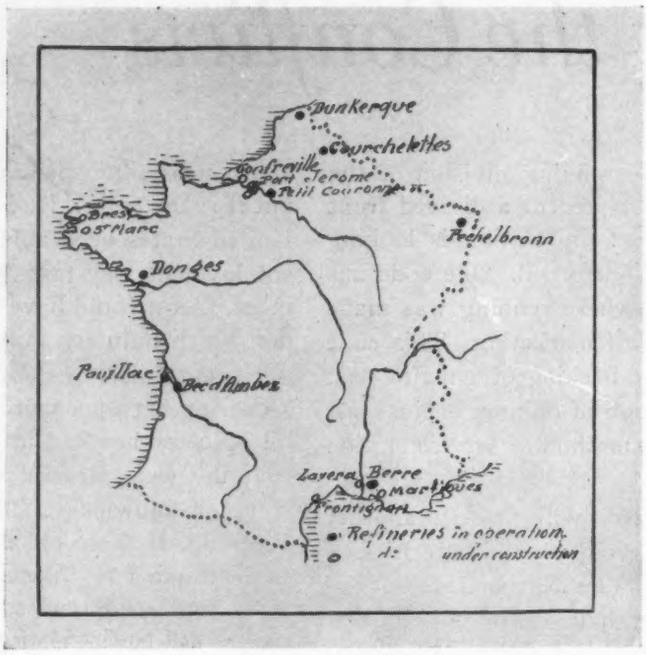
Sound thought dictates the determination to get rid of conflicts before going down to Washington.

France Long Has Encouraged National Refining Industry

M. FILHOL
Head of the Bureau of Information of the French Petroleum Department

THE idea of creating a refining industry in France is far from being a new one.

In view of favoring the development of a national refining industry a law, enacted way back in 1863, stipulated that all crude oils introduced in France to be refined would be imported free of duty, the imported gasoline being charged with a tax of 10 francs per 100 kilos.



In 1873 the protection granted the French refiners was raised to Fr. 12.25 and remained as such up to 1881.

From 1881 to 1903 new laws successively reduced the protection until it amounted only to about one franc.

This meant the end of a prosperous industry, the refiners being then unable to win in their struggle against foreign competitors, and obliged to close their refineries and organize themselves as distributors of imported products.

In 1919, in order to encourage again the development of a French refining industry, a new law was enacted. This law which exonerated the crude oil imported by the French refiners to be treated in their refineries provided that taxes would only be collected on the refined products delivered by them, on condition, however, that they agree to submit their operations to the control and supervision of custom officers.

This step did not, however, prove sufficient to reach the object in view. The protection thus far granted not being great enough to allow the refiners to work successfully, new laws increasing their privileges were enacted in 1928.

WHY A NATIONAL REFINING INDUSTRY?

Opinions do not agree on the following question: Is it better to refine crude oil where it is produced and ship its products to the world markets, or to transport the crude oil to the consuming centers and refine it in plants located far from the oil fields.

Both theories are based on sound arguments and have their advocates. Judging from past experiences it would seem that the theory in favor of refining far from the oil fields and near the world markets has been gaining much ground. In any case it has been approved by most of the countries of western Europe, England, Germany, Italy, Spain, Belgium and France, countries which figure among the largest users of oil products and where important refining plants have been installed in the course of the last few years.

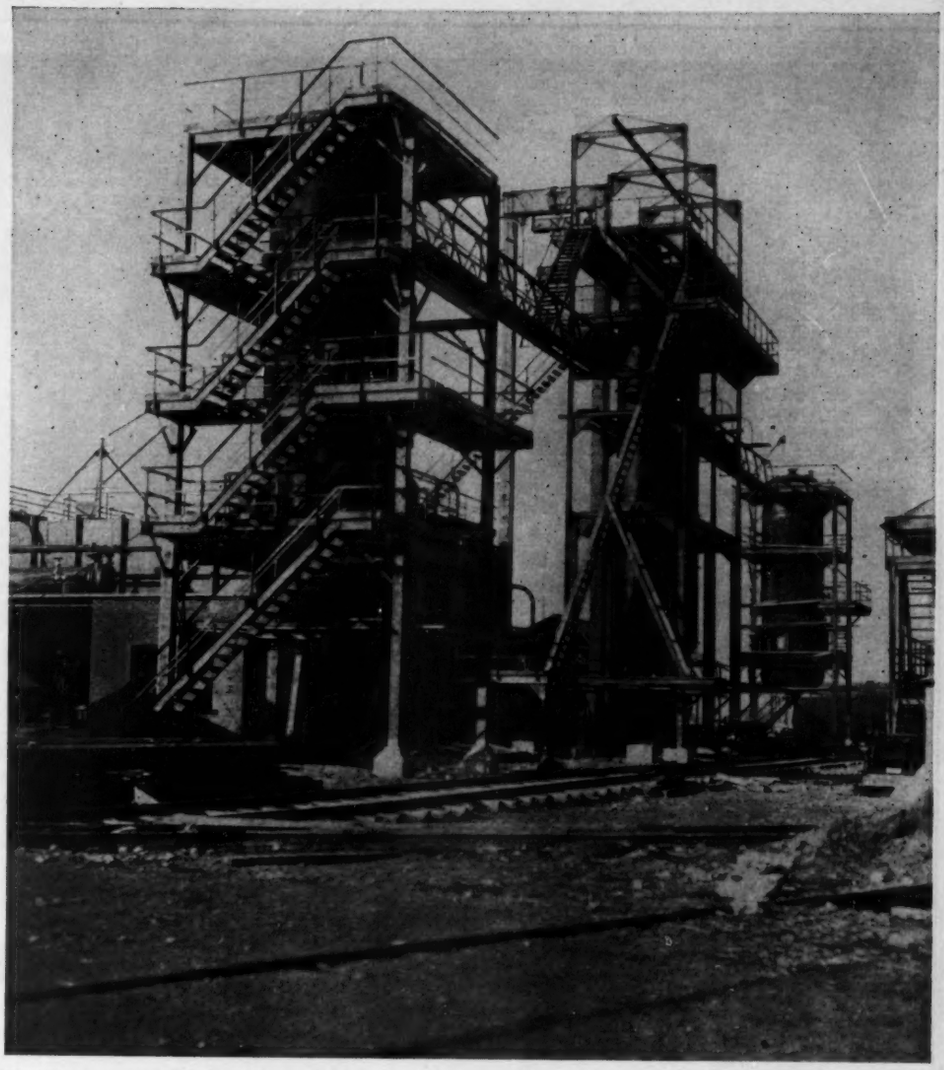
It is a fact that in most of these countries the creation of a refining industry has been partly explained by the necessity of maintaining large reserve stocks for use in times of emergency. This is most evidently an explanation of the greatest value.

But this is not, by far, the only reason and it would be inaccurate to neglect mentioning other arguments dealing with the economic development of said nations, the importance of which is not to be overlooked in times of depression.

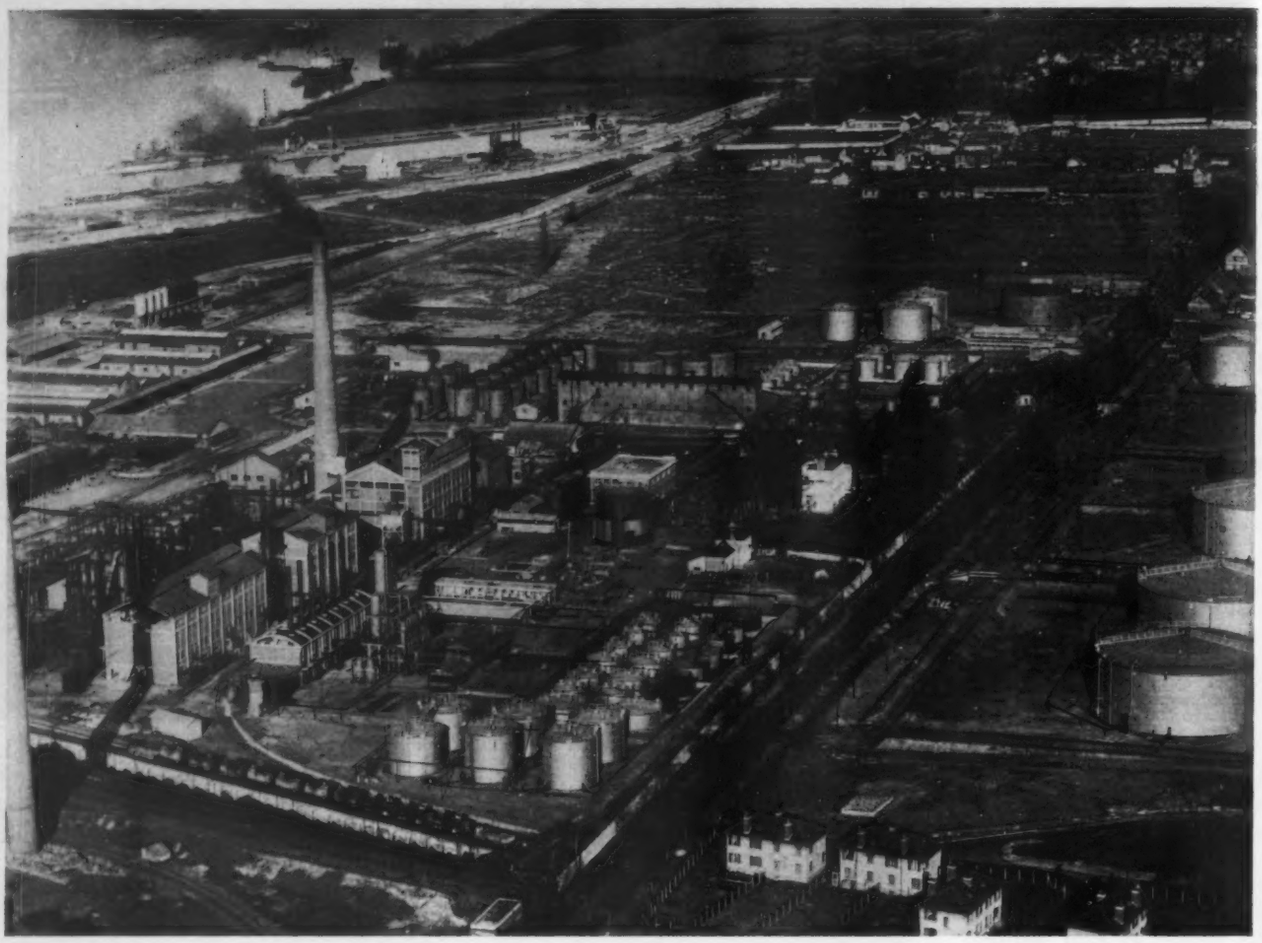
First of all it is to be noted that refining far from the oil fields has been practiced for a long time.

In the United States experience has shown that, owing to the successive exhaustion of the existing oil fields and the continuous discovery of new ones, it was irrational and costly to install refineries near the oil wells and to have to periodically remove them or to build new ones. It has, then, been found a better policy to create special refining centers which, in some cases, are distant from their sources of crude supply. This is, partly at least, the explanation of

Prosperous Industry of Fifty Years Ago Being Rebuilt, and Plants Are As Modern As They Are New



Two views of the plant of Campagnie Franco-Americaine de Refinage at Port Jerome.



—(Photo Compagnie Aerienne Francaise)

Raffinerie de Petit Couronne, Societe des Petroles Jupiter.

the immense development of the pipe line system of that country.

In Mexico, in spite of large and up-to-date refineries, a large proportion of the crude oil produced is regularly shipped to refineries located, in some cases, very far away.

In Colombia and Venezuela the situation is still more convincing, about 90 per cent of their crude oil production being treated in foreign refineries.

These facts would certainly tend to show that at least some members of the oil industry are favorable to the idea of refining far from the centers of production.

The advantages resulting from this method are many. Let us mention some of them.

It is evidently cheaper to transport the crude oil than its distillates.

It is more rational to give to the consuming country the benefit derived from refining operations, employment of national labor, use of national manufactured products, collection of taxes, etc.

It is also more rational to refine the crude oil in the consuming country as it gives the refiners the opportunity of extracting from it the specific products called for by that country, in quantity as well as in quality.

Moreover, a national refining industry may serve as a useful base to develop a profitable export business of refined products.

It is for these various reasons that the French Parliament was invited, on the request of the Office National des Combustibles Liquides, that is to say the French Petroleum Department, to pass the customs law of March 16, 1928, which law, by creating new tariffs imposed on petroleum products imported into France, favored the import and treatment of crude oil by French refineries. In fact the protection granted these refineries amounted to Fr. 105 per 1.000 liters of gasoline and kerosene, Fr. 330 per metric ton of lubricants, etc.

Moreover the law of March 30, 1928, regulated the importation of oil and oil products into France.

Deeming it necessary to give the French refiners a guarantee as to the stability of their operations, without which they would be unable to invest safely the funds necessary to the construction of their plants, the French legislators granted them, instead of the ordinary three-year import permit provided by the law for the regular importer of foreign oil

products, a 20-year permit. This permit did not however apply to the importation of a specified amount of crude oil, but to the quantity of oil products extracted from it in the home refineries and to be sold on the domestic market.

This repartition was attended to without the least discrimination, the right of each importing company being most scrupulously examined by a special ministerial committee. In fact the law guaranteed to each company already importing a right to an authorization for a quantity equal to the maximum quantity imported during the previous five years. This amount was, indeed, greatly enlarged from time to time according to the increasing needs of the French market.

The firms authorized to install a refinery in France were granted import permits which correspond approximately to the treatment in their plants of the following amounts of crude oil:

1. Societe Franco Americaine de Raffinage (Standard Oil Company, New Jersey), 1,000,000 tons.

2. Societe des Petroles Jupiter (Royal Dutch-Shell), 750,000 tons.

3. Societe Generale des Huiles de Petroles (Anglo-Persian Oil Company, Ltd.), 450,000 tons.

4. Societe des Raffineries de la Vacuum Oil S. A. F. et de la Compagnie Industrielle des Petroles, 350,000 tons.

5. Compagnie Francaise de Raffinage, 950,000 tons.

6. Societe d' Exploitations Minieres de Pechelbronn, 180,000 tons.

7. Raffinerie de Petrole du Nord, 280,000 tons.

8. Societe "Les Consommateurs de Petrole," 40,000 tons.

9. Compagnie des Produits Chimiques et Raffinerie de Berre, 376,000 tons.

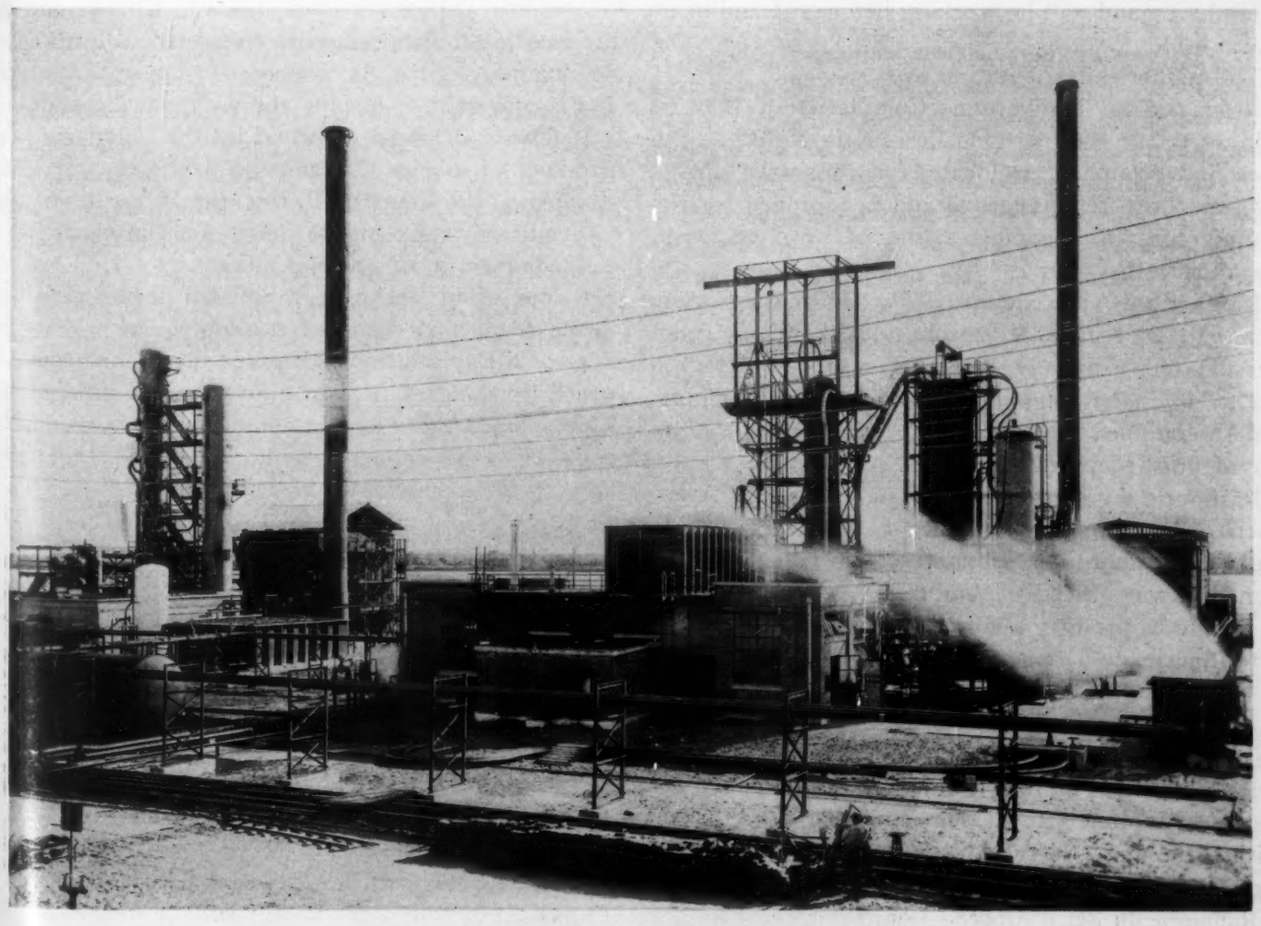
10. Societe des Raffineries de Petrole de la Gironde (The Texas Company), 270,000 tons.

11. Societe Brest Port Petrolier, 200,000 tons.

At first there were some doubts concerning the eventual result of the new legislation. The protection given to the products refined in France was claimed in some quarters to be insufficient, and later on the effects of the world economic crisis caused much apprehension.

In fact no better results could be expected than those actually achieved.

At present (April, 1933), eight refineries are completed and in operation, several others are nearing



Raffinerie du Bec D'Ambez, Raffinerie de la Gironde.

Compagnie des Produits Chimques et Raffinerie de Berre.

completion and will be working before the end of the year.

The refineries in operation are:

Raffinerie de Dunkerque—Completed in 1932, it belongs to the Raffinerie de Petrole du Nord and the Petrofina group. It is located on the water's edge near the Port of Dunkerque and is equipped for the manufacture of a complete line of products, with cracking units.

Raffinerie de Courchelettes—Owned by the Societe Generale des Huiles de Petrole, subsidiary of Anglo-Persian Oil Company, Ltd. It was completed in 1927. The installations include a battery for topping, and so equipped that they can produce a large number of finished products.

Raffinerie de Petit-Couronne—Constructed by the Societe Anonyme Jupiter (Royal Dutch-Shell), on the Seine, about 15 kilometres downstream from Rouen, it was officially inaugurated in January, 1933. It is able to produce a complete line of products.

Raffinerie de Donges—This plant which belongs to the Societe "Les Consommateurs de Petrole," and is only equipped for the manufacture and treatment of dark products.

Raffinerie de Pauillac—Property of the Societe des Petroles Jupiter (Royal Dutch-Shell), is equipped with a topping and cracking outfit and now operating.

Raffinerie du Bec d'Ambez—Located at Bec d'Ambez, near Bordeaux, belongs to the Societe des Raffineries de Petrole de la Gironde in which The Texas Corporation has recently acquired a large interest. This is one of the most up-to-date refineries completed in France under the new regime. It commenced to operate last year and is equipped for topping and with cracking units.

Raffinerie de Berre—Owned by the Compagnie des Produits Chimiques et Raffinerie de Berre, this plant, situated on the Etang de Berre, near Marseilles, is able to manufacture a complete range of oil products. It is also equipped with cracking units.

Raffinerie de Merkwiller—Situated near Strasbourg, in the production center of the concession held by the Societe d'Exploitations Minieres de Pechelbronn, to which it belongs, this plant draws most of its crude oil supply from the Pechelbronn field. It is complete, equipped with a cracking plant and able to manufacture all sorts of liquid fuels and lubricants.

THE REFINERIES NEARING COMPLETION

To this number of refineries equipped with a quite modern material and already in operation, must be added several others which are under construction and are expected to be completed before the end of the current year.

These refineries are:

Raffinerie de Port Jerome—Installed by the Vacuum Oil Company, S.A.F. et Compagnie Industrielle des Petroles, on the Seine River, between Havre and Rouen, opposite the village of Quillebeuf.

Raffinerie de Port Jerome—Erected by the Societe Franco-Americaine de Raffinage, subsidiary of the Standard Oil Company (New Jersey), not far from the refinery of the Vacuum Oil Company. This plant which

will be complete and up-to-date in every respect, is expected to be in operation very shortly.

Raffinerie de Gonfreville—Built by the Compagnie Francaise de Raffinage, subsidiary of the Compagnie Francaise des Petroles will be one of the most important oil plants in France when completed. It is expected to commence operating in 1933.

Raffinerie de Lavera—Erected by the Societe Generale des Huiles de Petrole, subsidiary of the Anglo-Persian Oil Company, Ltd., near Port de Bouc on the Etang de Caronte, not far from Marseilles.

Raffinerie de Frontignan—Installed by Vacuum Oil Company, S.A.F. and Compagnie Industrielle des Petroles.

Official information has not been published by the various companies concerning the daily refining capacity of their plants but it may be admitted that this capacity will, in every case, be sufficient to treat the amount of crude oil allowed to each of them.

From the remarkable results already obtained in the development of the French refining industry it would not seem that the companies refining in France have had to suffer from the state's interference, from the inefficiency and laziness of the French personnel em ployed by them, from the handicap due to the control of customs men, etc.

The obligation imposed on the French refiners to buy as much as possible of the material necessary for the erection of their plants from French factories is justified by the special protection accorded them.

It is inexact to say that such obligation is detrimental to the refiners. Whenever a refiner asks for the right to import some equipment which, in his opinion, is not to be found in France in satisfactory condition, his claim is examined by a special committee and he is regularly authorized to do so if it is proved that the articles cannot be manufactured in France.

It is inexact to say that the equipment bought from French manufacturers is below the standard found in the United States. Letters are on file at the Office National des Combustibles Liquides showing that some refining companies have equipped their plants only with French materials and have done so to their entire satisfaction. Such is the case, among others, for the Societe des Petroles Jupiter (Royal Dutch-Shell) in its refinery of Petit-Couronne. It may be added that this company has declared that, for the control and regulation equipment, the French manufacturers are equal to any others.

As to the French personnel employed in the refineries one needs only mention the fact that all the engineers composing the staff of the refineries have been selected from graduates of the best French schools, and are thoroughly conversant with the art of refining.

It is true that it has been found necessary to train foremen and workmen to their new work in refineries but it is unfair to explain the difficulties encountered by some companies in running their plants regularly from the beginning by such arguments as the inefficiency and laziness of their employes.

It is known everywhere, even in France, that a refinery cannot afford to shut down for days or weeks. But whatever may be the earnestness and the efficiency of the personnel, what can such a personnel do when the crude oil to be refined is not at hand? One might think of the difficulties new companies are liable to experience, mostly in times of depression, in starting operations and straightening their financial situation.

As to the presence of customs men at the refineries it is easily explained by the application of the rules enacted in the interest of the refining industry and to protect it. Can, however, anyone honestly pretend that the interference of the customs officers is an annoyance encountered only in France. Being international, most of the companies refining in this country know all about such interference in various countries, even in the United States, and this may be the reason why they accept the customs requirements, preferring to comply rather than be deprived of the protection they enjoy.

Raffinerie de Dunkerque, Raffinerie de Petrole du Nord-Petrofina.

Removal of Hydrogen Sulphide *from* High Sulphur Gases

PHILLIP J. WILSON, Jr.
Chemical Engineer

WITHIN little more than a year three new processes for the removal of hydrogen sulphide from high sulphide gases have been described [2, 4, 5]. In each case the hydrogen sulphide is washed from the gas by use of an alkaline solution which, when fouled, is regenerated for further use by boiling. The essential difference in the three processes lies in the solutions employed, in one case a triethanolamine solution, in another a suspension of magnesia, and in the third a salt solution saturated with calcium hydroxide. In addition to these reagents solutions of sodium carbonate and of ammonia have also been used for gas purification in a similar manner, and it appears probable that other compounds will be added to this list.

In view of the lively interest in gas purification and the number of reagents which have already become available, it is believed that a brief description of the principles on which the processes are based, together with a comparison of the performance and properties of the solutions employed, will prove of value. Since little information on the results actually obtained with any of the solutions is available, several of the important factors can only be indicated in this article.

The concentration of H_2S in gas may vary all the way from a few grains per 100 cubic feet up to 10 and 20 per cent by volume, and in the case of refinery still gas even higher concentrations have been encountered. The low sulphur gases, which includes those containing up to 500 grains per 100 cubic feet, can usually be cleaned by the methods which are commonly employed for the purification of manufactured gas, such as the Seaboard process or oxide boxes; and in many cases attempts have been made to employ the same methods for the purification of high sulphur gases as well.

The Seaboard process is a continuous, cyclic process in which a solution of soda ash is used in a packed tower to wash the hydrogen sulphide from the gas, and is then regenerated for further use by blowing with air in a similar tower. It has often proved satisfactory; but the high concentrations of hydrogen sulphide and the pressures under which the gases are frequently handled would in other instances necessitate the installation of plants of excessive size. Such installations would prove expensive to operate and their permanent character would prohibit removal of the plant to a new location. Solid ferric oxide is used in oxide boxes for removing the hydrogen sulphide from gas. The size of the installation, the large ground area needed, and the large amount of labor required for handling the oxide have in practically every case made this process too expensive.

The industrial operation in the case of all the reagents is much the same. The hydrogen sulphide is scrubbed from the gas in an absorbing tower with a solution or a suspension of the reagent until the solution is thoroughly fouled. This fouled solution is regenerated by boiling with steam in a still or actifier. The regenerated solution is then cooled and returned to the absorber. The vapors from the still can be cooled to condense the steam, and the hydrogen sulphide recovered in concentrated form. The flow sheet for a typical plant is shown in Figure I.

Hydrogen sulphide dissolved in solutions of many alkaline compounds tends to escape when the solution is exposed to the air. The magnitude of this tendency to volatilize or rather the hydrogen sulphide vapor pressure of the solution will depend on the reagent employed and the quantity in solution, the quantity of hydrogen sulphide absorbed, and the temperature of the system. If hydrogen sulphide is absorbed from a gas by such a solution, the hydrogen sulphide vapor pressure will increase as the H_2S concentration increases until it equals the partial pressure of H_2S in the foul gas. Under this condition the hydrogen sulphide will be returned from the solution to the gas as fast as it is absorbed, so that no further increase in the H_2S concentration of the solution can occur.

When the foul solution is heated to boiling, the hydrogen sulphide vapor pressure is materially increased, several hundred per cent in certain cases; and the H_2S is rapidly volatilized into the current of actifying steam until the partial pressure of the hydrogen sulphide in the steam is equal to the vapor pressure of that in the foul solution on the top plate of the still. This is the maximum concentration

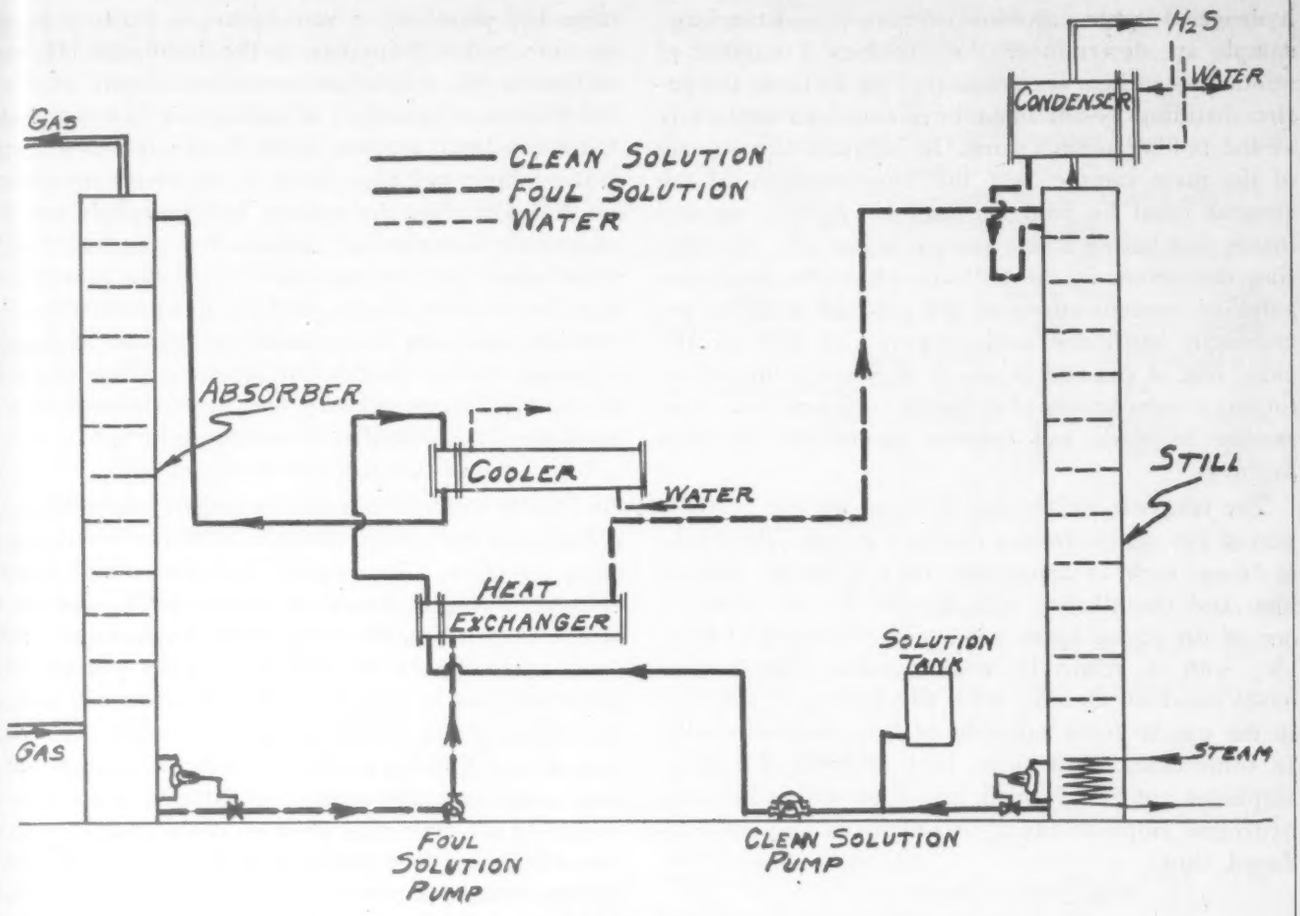


FIGURE 1

Gas purification plant using steam to clean the solution.

which the steam will carry. Since the steam as generated contains no hydrogen sulphide, it should be possible to reduce the H_2S vapor pressure of the solution to zero; but in practice this degree of efficiency is never attained. The clean solution always leaves the still with a small hydrogen sulphide vapor pressure which is lowered materially when the solution is cooled. The H_2S vapor pressure of the cold, clean solution obviously determines the minimum concentration below which it is impossible to reduce the hydrogen sulphide content of the gas. Enough steam must therefore be generated in the still to clean the solution to such a concentration that the gas can be adequately purified.

Just as in the case of other absorption and distillation processes, the hydrogen sulphide vapor pressures of the absorbing solutions under the different conditions may be plotted in the form of curves. Typical curves for triethanolamine solutions are shown in Figure II; the lower curve shows the vapor pressure of the solution used in the absorber while the upper curve represents the same solution at the boiling point. When used in accordance with any of the methods for the study of absorbers and fractionating columns, such as the graphical method of Walker, Lewis, and McAdams[1], such curves will prove useful for comparing the performance of different reagents or for plant design.

Although little data has been published on the vapor pressures of the different solutions, reliable curves may be readily prepared for the conditions under which a particular plant is to operate. In the case of a cold solution several points on the H_2S vapor pressure curve may be determined by bubbling the foul gas through some of the clean solution. The quantity of hydrogen sulphide in the outlet gas and that in the solution are determined at intervals. Or separate samples of the solution may be fouled with different quantities of gas. Air is then passed through each sample, and the H_2S content of the escaping air and of the sample determined. For accurate curves it is advisable to use both methods, and to use a solution which has been fouled and actified several times.

The hydrogen sulphide vapor pressure curves of a hot solution are more difficult to determine. A sample of the solution fouled with the gas to be purified is boiled, and small samples of the distillate are periodically collected in caustic. As each of these small

samples is taken, the volume is measured, and the hydrogen sulphide contents of both it and the large sample are determined. For accuracy a number of minor precautions are necessary; for instance the entire distilling vessel must be maintained uniformly at the boiling temperature. In addition the volume of the main sample and the concentration of the reagent must be held constant by making up any losses just before a test sample is run off. By plotting the curves in the units in which the hydrogen sulphide concentrations of the gas and solution are ordinarily expressed, such as grains of H_2S per 100 cubic feet of gas and grains of H_2S per gallon of solution, a comparison of different solutions can more readily be made and tedious conversions of units avoided.

The reagents which may be used for the purification of gas can be divided into two groups; the weaker bases, such as ammonium or magnesium hydroxides, and the alkaline salts formed by the union of one of the strong bases, sodium or potassium hydroxide, with a relatively weaker acid. The weaker bases combine directly with the hydrogen sulphide in the gas to form sulphide or hydrosulphide salts. In some cases, such as in that of triethanolamine, sulphides are first formed, and then with additional hydrogen sulphide the hydrosulphides may be produced, thus:

$$2NR_3 + H_2S = (NR_3H)_2S$$
$$(NR_3H)_2S + H_2S = 2NR_3H_2S$$

In the case of other weak bases, such as calcium hydroxide, the sulphide salt is hydrolyzed as soon as formed to the hydrosulphide:

$$Ca(OH)_2 + H_2S = CaS + 2H_2O$$
$$2CaS + 2H_2O = Ca(OH)_2 + Ca(HS)_2$$

All of these sulphides are readily decomposed on boiling with regeneration of the original solution and evolution of the hydrogen sulphide.

To the class of weaker bases belong ammonia, magnesia, lime in salt solution, and triethanolamine. The latter is the only organic compound which has been successfully employed on a commercial scale, but it is possible that further work in the organic field will add others to this list. The hydrogen sulphide vapor pressure curves of one of these solutions usually rises in a smooth curve from the point at which H_2S is first absorbed to the point where all the base is converted to the hydrosulphide salt, with possibly a break at the H_2S concentration corresponding to complete conversion of the base to the sulphide salt with no hydrosulphide present. Figure II, showing curves for triethanclamine, is a typical example; although in this case the point where hydrosulphide formation begins has not been reached.

A strong base, such as sodium hydroxide, reacts with hydrogen sulphide to form first the sulphide and then with more H_2S the hydrosulphide, as in the case for triethanolamine. A sodium sulphide solution has practically a zero hydrogen sulphide vapor pressure; but with increase in the hydrosulphide concentration this vapor pressure rises slowly at first, and then more rapidly. On boiling the hydrosulphide solution a large portion of the NaHS is driven back to the sodium sulphide, but it is only with the greatest difficulty that the sodium hydrosulphide can be completely decomposed. However the hydrogen sulphide vapor pressure can be reduced low enough so that the solution can be used for gas purification.

Other acids act in a similar manner to hydrogen sulphide, carbon dioxide for instance. The reaction of sodium carbonate with hydrogen sulphide is almost identical with that of sodium sulphide:

$$Na_2CO_3 + H_2S = NaHCO_3 + NaHS$$

On boiling the foul solution hydrogen sulphide is expelled, and the carbon dioxide from the bicarbonate takes its place. The original solution would eventually be obtained, if it were not for the loss of some of the carbon dioxide along with the hydrogen sulphide. As a result of this loss all the sodium sulphide will not be decomposed, and continued use of the solution will result in almost complete conversion of the Na_2CO_3 to Na_2S. Thus an actified solution containing 100 grams per liter of sodium carbonate at the start may after repeated contact with a gas containing 3000 grains of H_2S per 100 cubic feet and over two per cent CO_2 carry 2000 grains of H_2S per gallon. If the sodium carbonate were all converted to sodium sulphide, the solution would contain about 1800 grains of hydrogen sulphide per gallon. In this case in addition to the Na_2S some sodium hydrosulphide is obviously present. In each cycle this solution will remove from the gas only a fraction of the quantity of hydrogen sulphide which it carries, between 400 and 500 grains per gallon; so that the H_2S concentration in the foul solution going to the still is increased to 2500 grains per gallon. Other acids which are less volatile than carbon dioxide so that they are not lost from the system may also prove practical, but of the salts of strong bases combined with weak acids only sodium carbonate, or rather sodium sulphide, has been employed commercially for gas purification.

Before comparing the characteristics of the commercial reagents, the influence of the carbon dioxide in the gas must be mentioned. In addition to hydrogen sulphide, CO_2 is often present in both refinery gas and natural gas. It reacts with all the absorbents for hydrogen sulphide to form carbonates, but any reagent thus combined is unavailable for the absorption of hydrogen sulphide. Consequently when any carbon dioxide is removed from the gas, less hydrogen sulphide is absorbed per gallon of solution. Less H_2S per gallon means a larger volume of solution to be circulated, and more solution in turn requires more steam for boiling. H_2S and CO_2 are not ab-

sorbed with equal speed by all reagents, however. In some cases as much carbon dioxide as hydrogen sulphide will be taken up by the solution in the absorber. Then the volume of solution necessary for purifying a given volume of gas containing CO_2 will be roughly twice as great as would be needed for the same volume of gas free from carbon dioxide, and the quantity of steam required for heating the absorbing solution will be doubled. In the case of other reagents nearly all the hydrogen sulphide can be removed from the gas before appreciable absorption of carbon dioxide occurs, and the quantities of solution and steam will not be affected greatly by the presence of carbon dioxide in the gas. In order to allow for the influence of the carbon dioxide content of a particular gas on an absorbing solution it is advisable to use representative samples of that gas in the preparation of the hydrogen sulphide vapor pressure curves.

Selective absorption of hydrogen sulphide and carbon dioxide has another advantage, the gases from the still can be more readily utilized because they contain a larger proportion of H_2S. For instance, a gas mixture containing 50 per cent hydrogen sulphide and 50 per cent carbon dioxide will not prove as satisfactory for the production of sulphuric acid as a gas, 95 per cent of which is H_2S.

Since the different conditions which may be encountered in practice, such as the quantity of carbon dioxide in the gas, do not affect the performance of the absorbing solutions to the same degree, a general comparison of the re-agents is difficult. However an effort has been made to indicate their relative merits by calculating the quantities and costs for steam and solution required in the purification of a typical high-sulphur gas by each of the following methods: lime in salt solution, triethanolamine, sodium carbonate, and ammonia. It has been assumed that a gas containing 1600 grains of hydrogen sulphide must be cleaned down to 80 grains, a removal of 95 per cent. In addition the gas will contain one per cent by volume of carbon dioxide, and will be under 35 pounds gauge pressure. The estimates, which will be found in Table 1, represent the author's opinion of the quantities of steam and solution which would actually be required in the normal operation of a plant with experienced operators. Although these figures may be changed by alteration in the conditions, it is not believed that their relative magnitude will be affected greatly. Insufficient data is available on which to base an estimate for magnesia; but this material will be discussed later.

Table 1 indicates that of the four materials compared triethanolamine has the lowest costs; for less steam is required for actification than with any other material. The quantity of steam increases successively in the case of ammonia, sodium carbonate, and

TABLE I

Comparison of Solutions for the Removal of Hydrogen Sulphide from Gas.

Assumed:
1600 grains of H_2S per 100 cubic feet of inlet gas
80 grains of H_2S per 100 cubic feet of outlet gas
95 per cent removal of H_2S
1 per cent by volume of CO_2 in inlet gas
35 pounds gauge pressure on gas.

	Weaker Bases			Alkaline Salts
Regent	**Triethanolamine**	**Ammonia**	**Lime in Salt Solution**	**Sodium Carbonate**
Concentration of Reagent	**40% Triethanolamine**	**30 g.p.l. NH_3**	**2.4 g.p.l. $Ca(OH)_2$ in 10% NaCl**	**130 g.p.l. Na_2CO_3 equivalent, present as Na_2S**
Grains of H_2S absorbed per gallon solution	930	1000	45	450
Gallons of solution circulated per 1000 cubic feet of gas	16.4	15.2	338	34.0
Grains H_2S per pound of steam to actifier	1350	333	64.3	250
Pounds of steam per 1000 cubic feet gas	11.3	45.6	236.6	61.0
Pounds of steam per gallon solution circulated	0.69	3.0	0.70	1.8
Cost of power for pumping solution per 1000 cubic feet of gas at 1¢ per HP hr. (50% pump eff.)	.03¢	.04¢	.67¢	.07¢
Cost of steam to still per 1000 cubic feet of gas at 25¢ per 1000 pounds	.28	1.14	5.92	1.52
Total cost of steam and power per 1000 cubic feet of gas	.31¢	1.18¢	6.59¢	1.59¢

lime in salt solution; and the sum of the steam and power costs for purification with each of these solutions is several times greater than it is for triethanolamine.

The figures for triethanolamine are based on a very complete description of the triethanolamine process made by Bottoms[2]. Triethanolamine is an organic compound, an amine, with properties similar in general to those of ammonia. In Dr. Bottoms' paper the hydrogen sulphide vapor pressure curves for 50 per cent solutions of this material, the concentration which is recommended for use, and other necessary data for plant design and operation are presented. Typical hydrogen sulphide curves for such a solution, both cold and at the boiling point, have been shown in Figure II. Owing to the viscosity of the cold solutions, 50 per cent is possibly the maximum concentration which can be used, with 40 per cent a better average figure. In addition to the hydrogen sulphide it is assumed that a portion of the carbon dioxide is also dissolved, 0.6 per cent. In other words the CO_2 in the gas is reduced from 1.0 to 0.4 per cent. The gases from the actifier will consist of approximately 80 per cent H_2S and 20 per cent CO_2. Since the absorption of CO_2 by the tri-

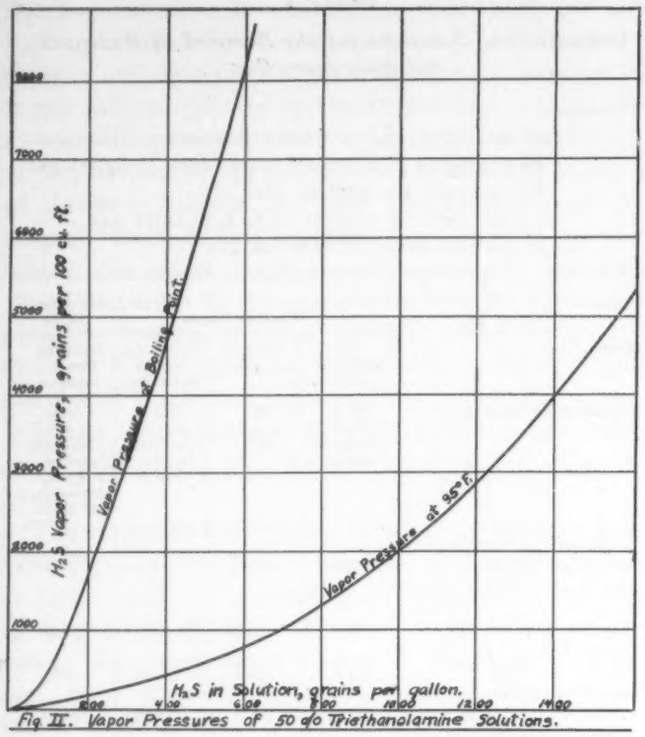

H_2S Vapor Pressure, grains per 100 cu. ft.
Vapor Pressure at Boiling Point
Vapor Pressure at 95°F.
H_2S in Solution, grains per gallon.
Fig II. Vapor Pressures of 50 o/o Triethanolamine Solutions.

FIGURE 2

ethanolamine increases the requirements of steam and solution, lower concentrations of carbon dioxide in the raw gas will naturally tend to decrease the costs.

Triethanolamine has been continuously employed in two gas purification plants for as long as two years and is still being used. This period of trial has demonstrated the practicality of the process, and much experience must have been gained which will be useful in future installations.

Considerable experience has been gained in the handling of ammonia and hydrogen sulphide together in manufactured gas. On a number of coke oven plants the ammonia is recovered from the gas by washing with water. At the same time large portions of both the H_2S and CO_2 also present in the gas are dissolved. The dilute solution of ammonium carbonate and ammonium sulphide is then distilled in order to recover the ammonia in a concentrated form, free from either of the acid gases. This is done by feeding the solution into a fractionating column in which by proper control of the conditions much of the hydrogen sulphide and carbon dioxide may be driven off at the top, while the ammonia is retained in the solution leaving at the bottom. The ammonia is then distilled off in another column, the last impurities scrubbed out in a suitable washer, and a pure ammonia vapor is obtained. If desired this could be returned to the unpurified gas for removal of more hydrogen sulphide.

Such a cycle is the basis for a number of processes of which the following is typical[3]. The hydrogen sulphide and carbon dioxide are scrubbed out of the gas with an ammoniacal solution. This solution is distilled to expel the H_2S and CO_2, and the ammoniacal solution left is returned to the absorber. The ammonia that is carried out of the H_2S absorber by the clean gas is recovered with water in another scrubber. This second solution is then used to wash the foul gas in a third scrubber located before the regular H_2S absorber, and in so doing gives up much of the ammonia which it contains to the gas. With ammonia in the foul gas entering the regular H_2S absorber less ammonia will be vaporized from the first absorbing solution, and the capacity of that solution for hydrogen sulphide is increased. These two processes illustrate the two ways in which ammonia may be used; first, as a gas added to the foul gas before the H_2S absorber in sufficient quantities so that all the ammonia and hydrogen sulphide is washed out as ammonium sulphide; and second, as a solution of ammonium hydroxide. In the second case the ammonia vaporized by the gas must be recovered. It is obvious that with either arrangement a more complicated plant than the simple process outlined in Figure I will be required, and considerably more skill and attention will be needed for operating it, particularly for separating the ammonia from the hydrogen sulphide and carbon dioxide boiled off from the solution in the still. This is evidenced by the fact that most of the processes which have been tried have proved unsuccessful, due to the excessive losses of ammonia. With present market prices for ammonia this difficulty becomes less important, and it is possible that an ammonia process can be considered in those cases where a very cheap supply is obtainable.

Little data is available as to the hydrogen sulphide vapor pressures of ammoniacal solutions, even in the range of concentrations encountered in the manufactured gas industry; but the volatility of ammonia from its aqueous solutions serves to increase the range of possible conditions very greatly. When carbon dioxide is present in the gas as well, the conditions become still more complicated. Too much reliance cannot be placed therefore on estimates of the performance of ammoniacal solutions unsupported by actual operating results.

In the coke oven industry the ammoniacal solutions which are distilled are relatively dilute, 5 to 15 grams of ammonia per liter; and their carrying capacity for hydrogen sulphide will be around 400 or 500 grains per gallon. If solutions with these low concentrations were used for gas purification, the steam requirements would prove prohibitive. More concentrated solutions will therefore be necessary, but undoubtedly an upper limit exists beyond which it will be impractical to increase the concentration of the ammonia. Since no definite indication of the maximum ammonia concentration is available, 30 grams per liter of NH_3 has been arbitrarily selected;

and the quantities of solution and steam estimated on this basis from experience with manufactured gas operations. Any change in the ammonia concentration will alter the solution and steam roughly in an inverse ratio.

The figures for sodium carbonates are based on actual plant operating results. They indicate that sodium carbonate will prove an expensive reagent, and this conclusion is confirmed by the fact that in spite of all the attempts made over a period of years to purify gases with sodium carbonate or sodium sulphide solutions regenerated by boiling there is but one plant using it on a commercial scale today.

As much as 15 per cent of soda ash may be used in a fresh, cold solution without danger of precipitating sodium bicarbonate. Since the sodium sulphides are more soluble than the bicarbonate, the concentration of salts may be increased if desired after the solution has been fouled several times. Such an increase might improve the figures in the table a little, but any decrease in solution or steam should not be proportional to the added quantity of reagent in the solution.

The use of lime in a concentrated salt solution is a process which has been described recently[4]. In order to overcome the disadvantages attendant on handling a suspension of lime, a solution containing between 7 and 12 per cent of sodium chloride is used. In this solution as much as 2.4 grams of calcium hydroxide may be dissolved per liter; but even this solubility is still too low for the hydrogen sulphide absorption of such a solution to compare with that of other reagents. If the calcium hydroxide, assuming 2.4 grams per liter were all converted to Ca $(HS)_2$, the solution would carry 129 grains of H_2S per gallon. But the carbon dioxide in the gas will precipitate calcium carbonate, and it is probable that practically all the carbon dioxide will be removed in this way at the same time that the hydrogen sulphide is absorbed. Removal of one per cent CO_2 from the gas as calcium carbonate will greatly reduce the absorbing capacity of the solution. In the case in question it should reduce it by 50 per cent or to about 65 grains of hydrogen sulphide per gallon. It is possible that as much as 45 grains of H_2S could be regularly absorbed, nearly 50 per cent more than the average absorption obtained in the plant on which data has been published.

No information has been published on the steam required for actifying a lime solution; but 0.7 pounds of steam per gallon of solution has been assumed in the table, the same figure that is used for triethanolamine. It is possible that considerably more might be required, but even on this favorable basis, the quantity of steam per 1000 cubic feet of gas exceeds that required by any other process.

Unlike the other reagents for gas purification, magnesia or magnesium hydroxide is employed in the form of a suspension[5]. The use of a suspension will present some special problems in the design of the apparatus, principally the insuring that enough of the solid reagent is actually circulated at all times to purify the gas properly. In addition deposits of magnesia must not be allowed to accumulate and plug the passages in the apparatus, so that the gas, steam, and solution are improperly distributed. In view of this possible difficulty it may be advisable to use packed towers or even mechanical washers instead of bubble plate columns when using magnesia.

Although magnesia has been employed on a small scale in one purification plant, no data is available as to the best type of apparatus or the characteristics of the suspension. A five per cent suspension was used in small scale laboratory experiments, and with such a concentration it is conceivable that results comparable with those for triethanolamine could be obtained.

In Table I no attempt has been made to indicate the magnitude of the other costs, such as labor, water, repairs, or loss of solution; but these factors also must be given some consideration. The labor requirements for all the processes should be the same, except in the case of ammonia. With this reagent the more complicated plant and the careful control demanded should require a greater amount of attention and skill. Water will in most cases prove to be a minor item. The volume will vary roughly with the quantity of solution which is cooled and the steam which is condensed.

The cost of the solution lost may prove more important. There are two ways in which losses may occur, by spills and leakage, and by the formation of fixed salts. Thiosulphates are formed in the solutions when in contact with air by oxidation of the sulphides, but they cannot be decomposed by boiling. Any reagent converted to the thiosulphate is consequently useless for further hydrogen sulphide absorption. The thiosulphate concentration will gradually increase until it affects the solubility of the reagent, and when this occurs solution must be discarded or worked up for recovery of the reagent. To reduce the rate of formation of thiosulphate the plant should be arranged in a closed system.

In the case of lime the calcium carbonate which is formed when the gas contains carbon dioxide will also increase the costs, because the CaO which is thus consumed must be replaced. In spite of all precautions to prevent spills and leaks, losses are bound to occur; so that it is desirable to use a cheap reagent or one for which supplies are readily obtainable.

Since the apparatus used in these plants is simple, the cost of repairs should not be great unless corrosion occurs. Solutions of all six reagents have been used for gas purification in ordinary steel apparatus; but little data is available to indicate that

with any one of the reagents corrosion is serious, except in the case of ammonia. Cast-iron stills are usually employed in the manufactured gas industry for the distillation of their ammoniacal liquors, but in certain portions of these columns aluminum or concrete-lined sections have been required. In general it is to be expected that the more alkaline a solution the less will be the tendency toward corrosion of the equipment.

It has been pointed out that the general arrangement of the plant in the case of all the processes, except that in which ammonia is used, is much the same, a simple cyclic process, illustrated by Figure I. The size of the plant will therefore be determined largely by the quantities of solution and steam to be handled. Solutions of triethanolamine or sodium sulphide will prove to be more dilute in the still than in other parts of the system. The solution in these cases is concentrated in the base of the still by the indirect steam in coils. In the condenser the steam and vapors are cooled and the condensate returned to the solution on the feed plate. The solution thus diluted is reconcentrated in turn when it reaches the base of the column. In the case of lime, allowance must also be made for the CaO converted to carbonate in the absorber. In view of these and other factors, a liberal margin of safety must be allowed in the apparatus sizes, until some actual plant operating data is available as a check on the calculations. Eventually, after more experience with these processes has been gained, it should be possible to construct stills and absorbers which will fit the conditions as closely as they do the conditions in other distillation processes.

Bubble plate columns, both for the absorber and the still, are desirable; but in those cases where the gas to be purified is close to atmospheric pressure it may be necessary to use an absorber packed with wooden hurdles or steel turnings in order to cut down the resistance through the column.

If the gas can be purified under pressure it is much easier to reduce the hydrogen sulphide to the desired concentration. Thus, if 50 grains of H_2S per 100 cubic feet of gas measured at standard conditions is the limit which cannot be exceeded, gas under atmospheric pressure must be scrubbed down to this concentration. But at 50 pounds gauge pressure the gas need only be purified down to the equivalent of 200 grains per 100 cubic feet of compressed gas, because when expanded to atmospheric pressure it will then contain 45 grains of H_2S. The H_2S concentration in the foul gas will be similarly increased; so that the solution can be more highly fouled, and a smaller volume can be circulated. Purification under pressure will often result in a marked reduction in plant size and operating costs.

The new cyclic processes designed for the purification of high sulphur gases by means of alkaline solutions, which are regenerated by boiling after having been fouled with hydrogen sulphide, are typical examples of the absorption and distillation process which employs a non-volatile absorbent for the removal of a volatile constituent from a gas. The hydrogen sulphide vapor pressure curves which may be prepared for solutions of such reagents as triethanolamine, sodium carbonate or sodium sulphide, and lime in salt solution will be of assistance in comparing these solutions and in plant design. Factors which may be important in a comparison of these processes are the per cent of carbon dioxide in the gas, pressure under which the gas is purified, loss of solution through formation of fixed salts and leakage, and in the case of ammonia its volatility, which will necessitate the use of a more complicated plant and increase the labor requirements. Although too little data is available on which to base an estimate for magnesia, its use in the form of a suspension may prove to be practical.

EDITOR'S NOTE

Not included in the foregoing discussion is the new Koppers Hot Activation Process for Gas Purification, recently briefly discussed by Col. G. A. Burrell and Nelson C. Turner in their paper "Advances in Technology of Natural and Refinery Gases" before the Third Petroleum and Natural Gas Conference of the Pennsylvania State College. The authors state, in part, that in the recently developed Koppers Hot Activation Process the hydrogen sulfide is washed out of the gas with sodium phenolate solution, made from caustic soda and tar acids. Foul solution is preheated in a heat exchanger, sent to the actifier where the H_2S is driven off by boiling with steam, the activated solution then being cooled and returned to the absorber. Vapors from the actifier are condenser cooled where the steam is condensed so that the H_2S is recovered in substantially pure form.

The solution of sodium phenolate has a very high absorbing capacity for H_2S, with the result that the quantity of solution per thousand cubic feet of gas is small, only 2 to 4 gallons per thousand cubic feet for a typical coke oven gas.

Little steam is required to activate the solution. Where gas is cheap reactivation is possible by direct heating with the gas rather than using steam. Apparatus is compact, small, with few moving parts; only one or two small pumps. A single-stage plant can remove 90 to 95 per cent of H_2S from the gas and wide variations in H_2S content of the gas may be handled without radical changes in plant operation. The cost of purifying coke over gas by this process is about the same as the cost of other purification processes. The gas can be readily burned to sulfur dioxide for the manufacture of sulfuric acid.

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Control of Filter Cakes In Contact Treating

L. C. TRESCOTT

IN the accompanying discussion of contact filtration of lubricating oils Mr. Trescott deals with the influences of clay texture and porosity, with acidity, alkalinity and moisture, as these factors influence the rate of flow and cake forming qualities of clay. He discusses also the results secured in filtering untreated oils, acid treated sour oils and acid treated oils which have been neutralized. Seemingly, and in a general way, it may be said that every effort should be made to avoid alkalinity of the filter cake where lubricants are filtered. Further discussion of this interesting topic is invited.

IN the field of contact treating lubricating oils little attention has been given to the matter of filter cakes and filter flow. Generally a type of clay is selected, and the filter plant layout worked up from some successful scheme already in operation. Often equipment at hand is pressed into operation. In any event filter rates are usually accepted as they come; variations are taken as being unavoidable and no great effort is made to go further into the matter.

The points which may influence and control the flow through this type of filter cake are many. It will be well to list some of them before going any further.

The original clay: These may be natural clays, as they come from the bank, or partially dried. They may be acid treated clays.

The oil under treatment: Sour, acid-treated oil; untreated stock; oil which has been treated and neutralized with alkali. Under this head will also come the viscosity of the stock, of "pepper" or fine acid sludge in the stock, the presence of wax or petrolatum, and of alkali or dissolved soaps.

The influence of water or moisture in any form.

As may be expected the real source of any trouble lies in the clay. Material of this sort is sedimentary, and with the more or less pure decolorizing material, a quantity of silt and material which is more or less colloidal is certain to be deposited. It is this colloidal material, influenced by the conditions of the process which gives the impenetrable cakes and cuts the flow-rate of the filter.

In preparing material of this sort no close mechanical grading is possible, as much valuable decolorizing material would be lost. Thus there is bound to be some variation in the proportion of colloidal material present and this variation is sufficient to show differences in flow-rates of different shipments from the mines.

Some natural clays are slightly alkaline in their reaction, or when tested will show a Ph value above 8. Such clays are very apt to form a colloidal, plastic filter cake with a lowered rate of flow. There are exceptions to this, but they are very few.

The acid-treated and high powered clays will usually give a good flow-rate. The acid condition of the clay produces a porous, non-plastic cake. The cake formed from the acid treated German clays is usually more porous, than that formed from the equivalent American clays. This is due to the manner in which the clays were originally deposited and to the texture of the treated clay. The foreign clays are usually more gritty; extreme fineness is usually gained by grinding, while most of the American acid treated clays usually go extremely fine on treating. The latter have a much softer texture and form a somewhat closer cake than the German product. While this clay runs to very fine particles, as a whole being much finer than any natural clay, the general nature of the material is not such as to form an impenetrable filter-cake. This statement applies as long as the cake is in an acid condition. As will be noted later, a slight degree of alkalinity gives a cake which quickly plugs a filter.

On a continuous rotary vacuum filter, operating on a medium automotive oil, it was found that the high powered foreign clays gave a cake which cracked easily on the filters. This cracking allowed an undue portion of air to go through and enough oxidation took place to give the clay a very poor showing as a decolorizing agent. The American product gave a smooth cake with little or no cracking. On a closed pressure filter this of course could not take place and the foreign clay would give equal

decolorization results with a higher flow-rate. The point does demonstrate the difference that a small degree of plasticity can make on a particular type of filter operation.

The second factor influencing flow-rate and cake formation is the oil under treatment.

An untreated oil presents the fewest difficulties as far as flow is concerned. If the oil be handled at sufficiently high temperature, that the viscosity or the presence of waxes has no effect, then it has little or no influence on the filter cake or the flow-rate.

Acid treated sour oil is usually free filtering, at least so far as the influence of the oil on the filter cake is concerned. It is possible that a sour oil which carries an undue quantity of fine acid sludge or "pepper" will give a bad cake, but all too often this too obvious reason is advanced when the actual cause of the low rate of flow lies somewhere else. In the case where the amount of pepper is high and the batch must be pushed through, the addition of from one per cent to five per cent of water by volume will flocculate the fine sludge and bring it down with the clay as a granular coke. In most cases this procedure will not affect the decolorizing value of the clay, although it will not work on all paraffin oils. A surprisingly large amount of pepper may be taken up in this way, although the problem is one in which each batch must be handled by itself.

Impenetrable filter cakes are often charged to petrolatum, but here it is obvious that if the temperature of filtration be high enough, there should be no trouble from this source. Care should be taken, however, that this temperature of filtration is really high enough. In one case where Pennsylvania cylinder stock was being filtered in a naphtha solution it was found necessary to go to 250°F. with the filtration. This was considerably above the melting point of any wax present, particularly considering the fact that the oil was in solution. Possibly something other than wax was responsible for the lowered filter rate, but the fact remains that an increase in filtering temperature from 175° to 250°F. gave an increase of flow far beyond that which might be charged to lowered viscosity only.

In the filtration of oils which have previously been treated and neutrallized with alkali, filter cake troubles often come from small quantities of free alkali, or from soaps which are not water soluble but which are dissolved in the oil. Material of an alkaline nature is most easily adsorbed by the clay. It will replace coloring matter already on the clay and drive it back into the oil. It also has a deflocculating effect on the clay particles and tends to cause a very tight, plastic cake. With an acid treated clay the acidity is usually high enough to overcome this effect, but all too often an impervious cake from a natural clay can be charged to this source. Sometimes the addition of a small quantity of acid to the oil will improve matters.

In general it may be said that every effort should be made to get away from alkilinity in a filter cake. The addition of alkalies, soda ash, etc., to the clay almost always causes a decrease in the flow-rate and gives a tight, rubbery cake.

In a case of this sort it is not always easy to work back on the oil and locate the source of trouble. An oil may be perfectly clear; may not show alkalinity; on steaming up it may break clear, and the water underneath be clear and free from any "rag," and yet it will carry sufficient soaps to give an impervious cake. Some samples can be washed with alcohol and the soaps shown by this means, but even that does not always tell the story. A bad filter cake from this source tends to be gray and rubbery. It will peel from the filter in a sleek sheet. It tends to gradually plug filter cloths, particularly twill woven cloths which have slight grooves in the weave. On the fingers it is smeary and greasy and clings to the skin.

Perhaps the most common cause of bad filter cakes is the presence of moisture in one form or another. It is rather surprising, considering the high temperatures used in contact treating, that this should be the case, but the fact remains. Here again an acid-treated clay has the advantage over a natural clay. The silt carried by the latter has an affinity for moisture and a tendency to slime.

While plenty of water should be used in the various stages of acid and clay treating, every effort should be made to have it out of the system before the oil-clay mix reaches the filters. Water usually gets to the filters because of some condensation taking place when the oil is cooled after leaving the contacting chamber. Sufficient opportunity must be given for the escape of steam after the highest temperature has been reached and before any cooling is allowed. Water will replace oil and coloring material on a clay even at a fairly high temperature. If free water does go back it invariably causes some sliming and to a greater or less degree gives an impervious cake.

Where the treatment has been carried out at a temperature above 300°F. little trouble will be encountered from free water that may have been on the clay when it was charged, provided sufficient opportunity has been given for it to escape. Even lower temperature than this may be used but extra care must be used to see that the water is all off. It must be remembered that as well as any free water, we have adsorbed water and water of crystallization which come off the clay only at high temperatures. If this water is driven off it must be led out of the system.

In this connection the writer has in mind a system in which the heating took place in two stages. The

first stage, going to 300°F. was well vented. The second stage carried the mix to 600°F. and at times as high as 700°F. After passing the final heater the mix was sent through heat exchangers without passing through a foam or vent tank. It was found that as high as six per cent of water was recondensed. The flow rate on the filters with this mix was low and trouble was encountered all through the system. The addition of a vented foam tank after the final heater and before the exchangers did away with such filter-cake trouble.

In this case the trouble was unquestionably due to adsorbed water and water of crystallization which had been driven off at the higher temperature and recondensed. Had this water been on the clay in its original state it would have given no trouble. Only when it was put back in the form of free water did it slime the cake. This example is given to emphasize the necessity of having all free water out of the system before the mix is sent to the filters.

The appearance of a bad filter cake caused by moisture differs somewhat from the cake from alkali or soaps. It is likely to be more gray in appearance than a good filter cake, but unless the cake is actually wet it will show a fairly open grain, and will probably not come off the filter in a sheet, or be very plastic. When rubbed between the fingers it will stick to the skin and act like a wet cake. Near the filter cloth it will be slimy and fine. It will not peel clean from the cloth and the cloth itself will be gradually plugged. On drying this fine slime seems to fairly bake into the cloth.

It may be said here that when a metal cloth has been plugged by either a wet or an alkaline cake, the most satisfactory method of cleaning it seems to be a fine spray of hot water. Gasoline or naphtha will hardly penetrate the slimy skin on the cloth and steam seems to dry out too quickly.

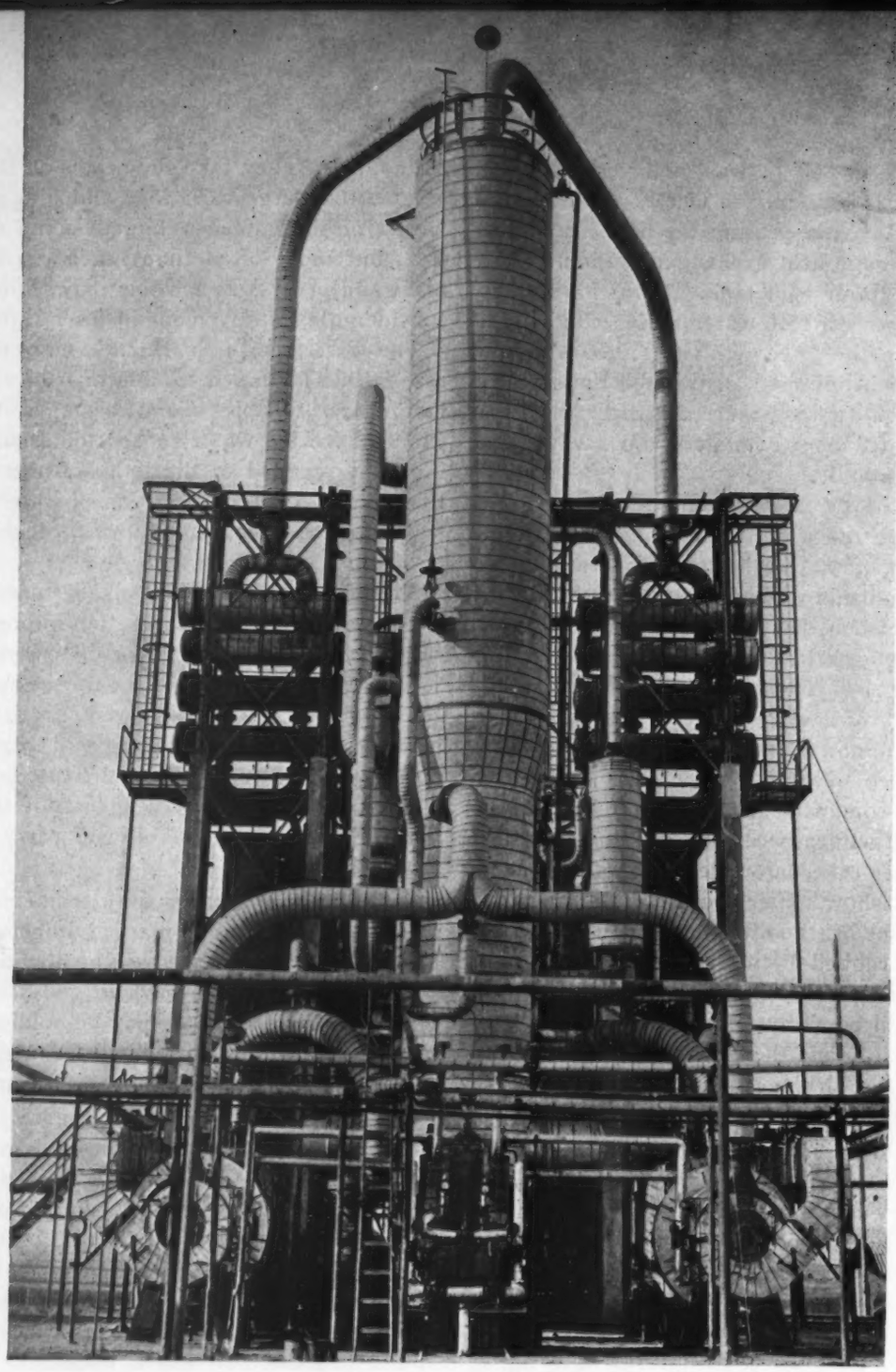
All too often operators of contact filter plants do not realize that they are not getting the most out of their filters. They take flow-rates as they come and assume that large variations and plugged cloths are a part of the game. While to some extent this is true, but more often than not a check-over of the plant and process as a whole may show means for a considerable improvement in filter rates.

The water condition which is more often than not responsible for much trouble may be checked in the laboratory. Samples from all stages of the process should have the water content determined, the heating being carried to the temperatures prevailing in that stage. As recondensation of water is a common source of trouble, possibilities of this should be checked.

The matter of soap and alkali sometimes requires a change in the process to get an improvement in the flow. In the case where the oil is actually alkaline further washing should clear up the matter. Where the trouble is due to dissolved soaps, and a natural clay is used, then a change to acid treated clay, or to a mixture of natural and acid treated clay will help. The dissolved soap condition is not usually permanent. Some batches of oil will carry more of this than others.

A little experimenting with temperatures of filtration often develops a marked improvement in the filter rate. Even in the case of filtration in naphtha solution it sometimes pays to go as high as 250°F. High melting point wax may be holding up the flow, or it may be that at a lower temperature a small amount of moisture is being picked up by the clay.

So far as the influence of the clay itself is concerned, there is little that can be done to change its original cake-forming qualities. As a rule the clay is chosen on an economic basis or for its particular decolorizing qualities. Flow rates seldom enter the matter at all. By using a little care, however, in keeping process conditions right, it is possible to get the maximum flow-rates from a given clay, and the effort will prove well worth while.



Operation of the Stratford Oil Circulation System in Roumania

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DACIA ROMANO PETROLEUM SYNDICATE, LTD., a British company operating in Roumania, is engaged in production and refining operations. Its production consists of two kinds of crude, typical of Roumania, namely Piscuri Drader non-paraffinous and Meotic paraffinous. These crudes are segregated in the fields and transported by pipe line to the refinery, a distance of approximately 30 kilometers.

The Stratford distilling unit was installed for the

purpose of manufacturing, from the above crudes, all commercial Roumanian products as well as for the purpose of making special products for export to other European countries.

The unit was designed and built so as to be suitable for any and all daily capacities ranging from 125 tons (1000 barrels) to 600 tons (4500 barrels) per day.

It has been operated at minimum capacity and has processed as high as 760 tons (5700 barrels) per 24 hour day, thus definitely showing its possibility as to capacity range.

The products which are usually demanded in Roumania are of the following specifications:

Light Benzene:

Specific Gravity, .730 max.
Engler Dist. E. P., 150°C. max.
Per cent off at 100°C., min 60%.

Heavy Benzene:

E. P. Max., 185°C.

White Spirit

Specific Gravity, .810 max.
I. B. P., 140°C. min.
E. P., 200°C. Max.
Flash, 29°C. Min.

Kerosene (French) paraffinous

Specific Gravity, .810.
Flash, 40°C. Min.
E. P., 280°C. Max.

Heavy Kerosene

Specific Gravity, .834.
E. P., 310°C. Max.

Gas Oil:

Specific Gravity, .880—.890.
Flash, 70°C. Min.
I. B. P., 200°C. Min.
E. P., 360°C. Max.

Residue:

Viscosity, 32 degrees Engler Max. at 50°C.
Flash, 140°C. Minimum.

The following is a brief description of the unit and its operation:

Crude is charged by means of a motor-driven centrifugal pump through vapor-crude exchangers on the light benzine and heavy benzine streams through a steam heater—(used only in starting the unit for water separation) thence to a horizontal type low velocity settler in which the varying precentage of water and B.S&M. are settled out. The settler is an electrically welded pressure vessel approximately two meters in diameter by 11 meters long.

The oil enters the separator at approximately 110 to 125°C. at which temperature a practically complete separation of water and impurities is easily accomplished.

The flow of crude to the unit is automatically con-

THE present article dealing with the Stratford Oil Circulation System was contributed by Stefan Dobrescu in the belief that the refining industry is interested in most recent developments of the system and its application.

The Stratford still was developed at the Avon, California, refinery of Associated Oil Company and consisted of installation of nozzles over fire sheets of shell stills and expense of revamping was justified by increased throughput (Refiner and Natural Gasoline Manufacturer, Vol. 7, No. 3, March, 1928, page 65, "Modernization of the Cylindrical Still").

Later, Stratford, when consulting engineer, installed the system at Crown Central Petroleum Corporation's refinery at Houston, Texas, using shell stills fitted with internal fire tubes against which oil was discharged through nozzles to completely cover the surface with a rapidly moving film of oil which absorbed and carried away all heat of combustion. Experiments showed a transfer rate in excess of 75,000 Btu/hr. Fuel consumption was low, being 0.75 per cent liquid fuel but when taking into consideration electrical energy required, circulating pump, air blower, etc. to make this fuel consumption possible, the unit consumption averaged 1.5 per cent. The particular difference in the 1928 design of still and the still erected in Roumania is that the original stills held a large bulk supply of oil and the firing tube was a flat cylinder, while the newer still employs a corrugated fire tube, and the annular space between the tube and outer shell is as small as is mechanically possible, circulation being affected with the bottom of the tower acting as bulk supply.

A description of the operation of the Stratford system over a period of 2½ years in the refinery of Steaua Romana, at Campina, Roumania, written by Stefan Dobrescu was published in 1931, in "Petrolul," published by Emile Severin, Professor of Technical Schools, of Bucharest, Roumania.

C. W. Stratford now is president and general manager for Alco Products International, an affiliate of Alco Products, Inc.

trolled by a Foxboro flow controller. The heated and dried crude then passes through convection sections 1 and 2 (to be described later) and thence under the eighth plate of fractionating bubble tower No. 1.

Tower No. 1 is that from which light benzine is taken as an overhead product and the hot crude enters the tower under the eighth rectifying plate and above four stripping plates at a temperature of approximately 170-190°C.

A light benzine of the specifications given above is the top tower product removed under cold liquid reflux control, automatically regulated by a Leeds-Northrup anticipating controller.

Because of the very marked price differential existing in Roumania between light benzine and heavy benzine, it is advantageous from the economic point of view, to make a maximum extraction of light benzine at the same time manufacturing a product which fulfills the specifications in all respects.

Because of this economic manufacturing necessity, the base of the light benzine tower (No. 1) is equipped with a single pass, vertical, reboiler which is installed in a circulating line from the base of No. 1 tower and which re-enters the tower under the bottom plate.

Sufficient heat can be supplied to the base of No. 1 tower, by means of this re-boiler, to produce a gap between the end point of the light benzine and the initial boiling point of the white spirits of as much as 14°C. thus completely eliminating production of heavy benzine.

It is here to be pointed out that the performance of this fractionating tower gives supporting evidence to the theory that in order to produce a maximum yield of an overhead product of given end point, it is not only necessary to have no overlap between the end point of the overhead product and the initial boiling point of the next following product, but it is necessary to have a gap of several degrees.

Tower No. 1 is supported in the installation by Tower No. 5. Tower No. 5 is a vaporizer equipped with a centrifugal separating type of vaporizing head.

There is a 24-inch transverse pipe through the bottom of the vaporizer and to this pipe, on the outside of the tower, are attached two Byron Jackson oil circulation pumps.

The part of the 24-inch pipe within the vaporizer is perforated and screened to permit an easy flow of residuum to the suctions of the oil circulating pumps.

A liquid level, or positive head, over the suction of these pumps, is maintained by an automatic level control.

The oil circulation pumps each having a capacity of approximately 3500 gallons per minute at three atmospheres discharge pressure, discharge independently to each of two oil circulation heaters description of which follows:

From the two heaters, the discharge lines join and enter the centrifugal separating head of the vaporizer.

The hot crude from the base of No. 1 or light benzine tower, stripped of light benzine, is introduced into the stream of circulating oil entering the vaporizer, by which it is heated to distilling temperature. Since the quantity of circulating oil entering the vaporizer is approximately 60 times the quantity of the hot crude stream which is added to it, it is obvious that a very slight decrease in temperature of circulation oil provides the necessary quantity of heat to raise the incoming crude to distilling or vaporizer equilibrium temperature.

It is also to be remarked that because of the never changing quantity of circulation oil, the operation of the unit is entirely independent of the crude charging rate to the unit; that is the unit may be operated at very low or at very high throughput rates without any effect on the velocity of circulation oil flowing through the heaters.

From the above description of the vaporizer, it is seen that no crude oil ever reaches the oil circulation heaters and that the oil passing through them is at all times a residuum which, with the exception of final stripping of low boiling point components is a finished product and which passes through the heaters without vaporization.

The main vapor stream from the top of the vaporizer, passes to the base of Tower No. 2 under nine plates from the top of which heavy benzine is removed as product vapor under the same type of reflux and temperature control as Tower No. 1.

The condensed heavier fractions flow by gravity from the base of No. 2 tower to No. 3 tower into which they are introduced under nine rectifying plates and above eight stripping plates.

White spirits is removed in liquid phase from the first plate of No. 3 tower and is introduced into a four-plate stripping tower which is used for control of the flash point of the white spirits. Superheated steam is used for this control. French and heavy kerosene and gas oil are removed in liquid phase from the plates of No. 3 tower.

The level control on the base of the vaporizer, tower No. 5, controls a residuum draw-off from this tower to four residuum stripping plates in the base of No. 3 tower where the residuum is stripped of low boiling point components and reduced to viscosity by means of superheated steam.

The heat and superheated steam supplied in the base of No. 3 tower also serve as re-boiling media for gas oil, kerosene and white spirits.

The overhead benzine streams are completely condensed in tubular condensers and cooled by auxiliary

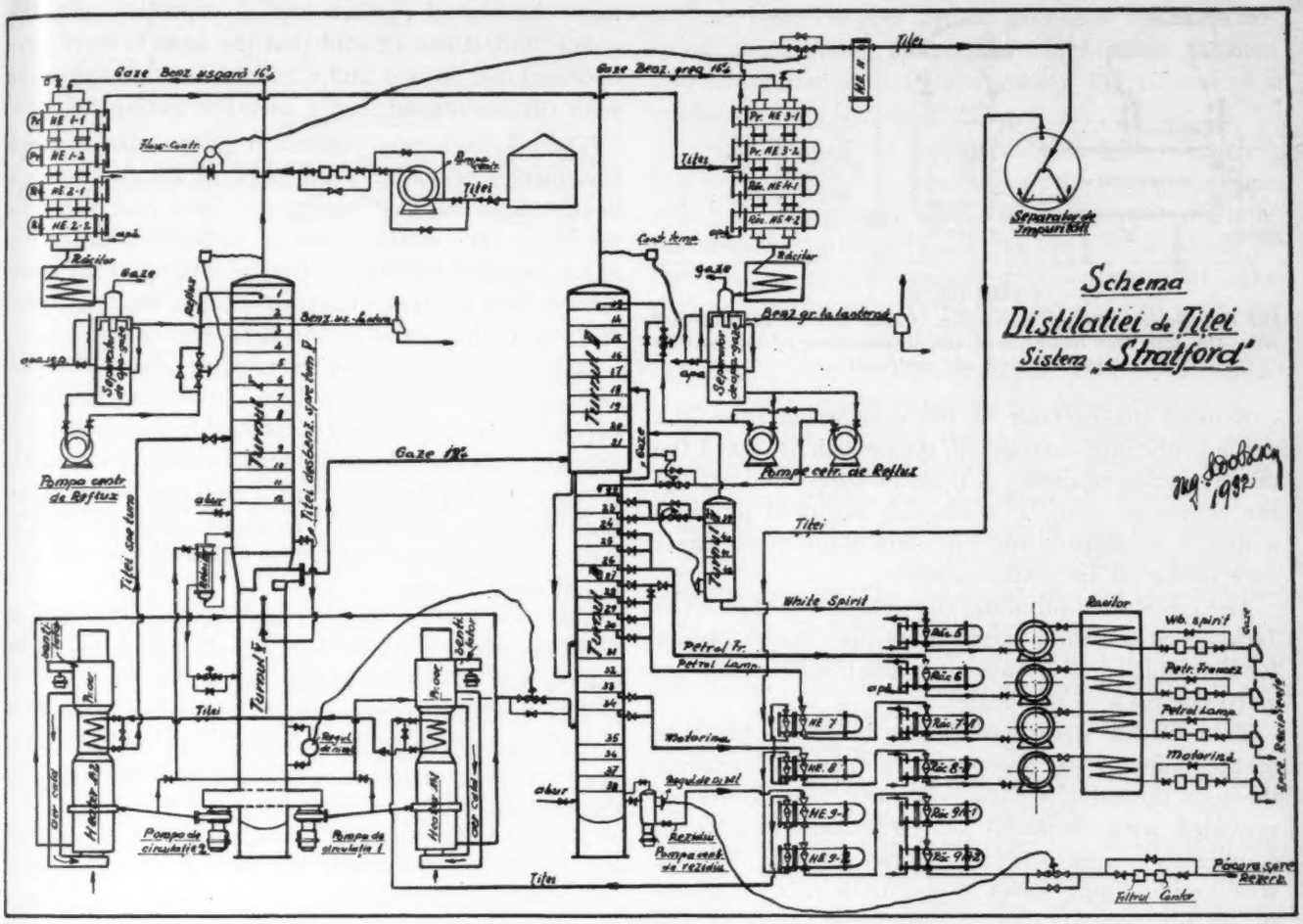

FIGURE 1
Flow Chart of Stratford Oil Circulation System

condenser boxes containing Sterling cooling sections.

They then pass through gas-water distillate separators through the receiving house and thence to storage. Dry reflux is withdrawn from these separators.

All liquid phase products are cooled by heat exchange against crude and tubular water coolers thence pass through the receiving house to storage.

All product lines with the exception of benzene, are equipped with meters and are pumped by motor-driven centrifugal pumps through the receiving house from which they flow by gravity to storage.

The unit is entirely electric driven. All the electric starting equipment is concentrated in a fire proof electrical control house, built at the end of the receiving house, and all motors are individually controlled by means of remote oil immersed push button stations located at the individual motors.

The receiving house is located on the second floor of a fire-proof building. The distilling unit with the exception of combustion, is controlled from an instrument board in this room. The ground floor of the building houses the centrifugal pumps for products and reflux.

The choice of the oil heating equipment for this installation was made after a very careful study of past performance and the suitability of the oil circulation system for the problem in hand.

Heretofore, oil circulation had been applied to bottom fired shell stills and shell stills equipped with corrugated firing tubes.

However, in this instance, it was desired to eliminate the expensive masonry and shell still construction as well as to reduce to a minimum the quantity of oil in the heater.

In addition, it was necessary to have a heating system which lends itself easily to the requirement of furnishing a heat carrying vehicle to the reboiler; namely, a circulation oil, without influencing the velocity of oil flowing through the heaters and independent of the oil charged to the unit.

In order to satisfy all the above conditions, oil heating equipment consisting of two Stratford inside fired oil circulation heaters, each composed of radiant section, tubular convection or economizer section and corrugated envelope type air pre-heater, was made.

The radiant section has a corrugated firing tube four feet in diameter by 12 feet over-all length and provides approximately 120 square feet of radiant heating surface.

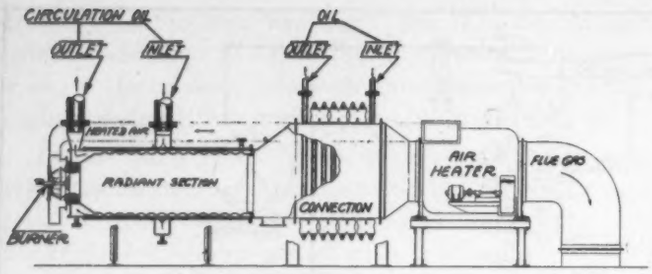

FIGURE 2

Oil Circulation Heater Assembly. Cross section showing oil flow through the heater and the application of convection section and air preheater.

Around the exterior of the corrugated tube is a second tube, not corrugated, into which are fixed the oil circulation nozzles. A third or outer shell around the center of which is a circular manifold provides a means of distributing circulation oil under pressure to the oil circulation nozzles.

The circulation oil under the pressure of the Byron Jackson circulation pumps enters the circular header for distribution two ways—toward the front and toward the back of the heater.

This oil thus distributed under discharge pressure of the pumps then dissipates its energy in passing through the oil circulation nozzles. The heater is provided with sufficient oil circulation nozzles to completely cover the corrugated heating surface with an impinging series of jets discharging oil flowing at high velocity (25/30 meters per second). The oil film flowing at high velocity permits extremely high radiant transfer rates through the fired sheet because: (1) The film temperature is maintained within a few degrees of the temperature of the main body of heated oil; (2) the high velocity film maintains the heated surface free of deposits. (In this connection, it can be said that the heaters have been operated over a year and a half without cleaning and with the maintenance of a metal-bright surface).

The oil discharged against the fired tube through the nozzles flows from the back to the front of the heater, between the corrugated tube and the tube retaining the nozzles, thus in addition to the flow of oil supplied by the nozzles, providing at all times a mass flow of large quantities of oil over the heated surface to the outlet at the fired end of the heater.

It is evident from the description above that the radiant section herein employed becomes a small inexpensive unit as easily replaceable as a heat exchanger tube bundle and which is readily adaptable to construction from corrosion resistant steels when the oils to be processed are highly corrosive. The flow of the oil may be readily followed in cross sectional view Figure 2.

The convection sections are of tubular design, with stream line return bends and each contains 94 square feet of inside heating surface.

The following figures show an approximate heat distribution through the heating units. All percentages are percentages of the total heat contained in the fuel oil:

	Per Cent
Radiant Oil Circulation Heaters	70
Convection Sections	8
Air Heaters	10
Stack Loss	7
Radiation	5
Total	100

From the above, it can be seen that the efficiency

Stratford Distilling Unit Dacia Romano — Ploesti
Yields

KIND OF CRUDE	Gravity at 15°C.	Throughput Tons per day	Light Benzine %*	Heavy Benzine %	White Spirit %	Kerosene %	Gas Oil %	Residuum %	Loses %	REMARKS
1 Piscuri non-paraf.	0.873	346	19.62	3.02	7.63	5.68	11.01	51.54	1.50	With one Heater.
2 Piscuri non-paraf.	0.873	362	19.36	6.07	5.44	3.02	15.93	49.29	0.89	With one Heater.
3 Piscuri non-paraf.	0.873	389	19.34	5.91	6.48	4.49	10.13	52.76	0.89	With one Heater.
4 Piscuri non-paraf.	0.873	392	20.05	4.76	4.49	5.28	11.94	52.08	1.40	With one Heater.
5 Piscuri non-paraf.	0.874	394	18.46	5.76	4.86	3.46	12.80	53.56	1.10	With one Heater.
6 Piscuri non-paraf.	0.873	400	18.71	5.37	5.78	5.00	12.12	52.28	0.74	With one Heater.
7 Piscuri non-paraf.	0.872	389	20.58	4.89	7.99	.....	15.62	49.36	1.62	One Heater-no Kerosene desired.
8 Piscuri non-paraf.	0.873	357	19.75	.....	12.17	6.66	8.09	52.33	1.00	One Heater-no Heavy Benzine desired.
9 Piscuri non-paraf.	0.872	396	19.23	.....	17.29	.....	12.88	49.77	0.83	One Heater-no Heavy Benzine, no Kerosene.
10 Piscuri non-paraf.	0.871	408	19.40	.....	15.43	.....	11.07	52.85	1.25	One Heater-no Heavy Benzine, no Kerosene.
11 Piscuri non-paraf.	0.875	480	17.75	.....	10.82	6.44	13.27	50.28	1.44	Both Heaters, no Heavy Benzine.
12 Piscuri non-paraf.	0.869	490	18.91	7.47	.....	13.68	7.45	51.55	0.94	Both Heaters, no White Spirit, Maximum Kerosene.
13 Piscuri non-paraf.	0.872	404	19.52	2.47	6.16	8.57	10.15	51.98	1.15	Both Heaters.
14 Piscuri non-paraf.	0.871	480	19.00	2.09	8.21	9.73	12.00	47.90	1.07	Both Heaters, more White Spirit, Heavy Residuum.
15 Piscuri non-paraf.	0.871	598	18.50	6.38	2.56	9.12	9.90	52.36	1.11	Both Heaters, more Heavy Benzine and Kerosene.
16 Piscuri non-paraf.	0.870	645	18.46	7.07	3.52	8.89	8.89	51.70	1.47	Both Heaters.
17 Piscuri non-paraf.	0.873	693	18.00	10.00	1.72	7.06	12.70	50.08	0.44	Both Heaters, Maximum Heavy Benzine.
18 Gura Ocnitei paraf.	0.840	560	18.00	6.85	.....	16.02	16.11	42.20	0.82	No White Spirits.
19 Gura Ocnitei paraf.	0.840	650	17.93	8.50	.....	11.42	18.10	42.81	1.26	No White Spirits.
20 Gura Ocnitei paraf.	0.840	700	17.50	7.40	.....	12.06	12.60	49.40	1.04	No White Spirits.
21 Gura Ocnitei paraf.	0.843	745	16.81	7.74	.....	13.97	16.55	44.00	1.03	No White Spirits.
22 Gura Ocnitei + Bustenari.	0.836	445	21.21	1.50	.....	18.06	15.04	43.17	1.02	No White Spirits.
23 Bustenari paraf.	0.832	540	22.23	7.61	.....	18.71	9.35	41.14	0.96	No White Spirits.

*All percentages by weight.

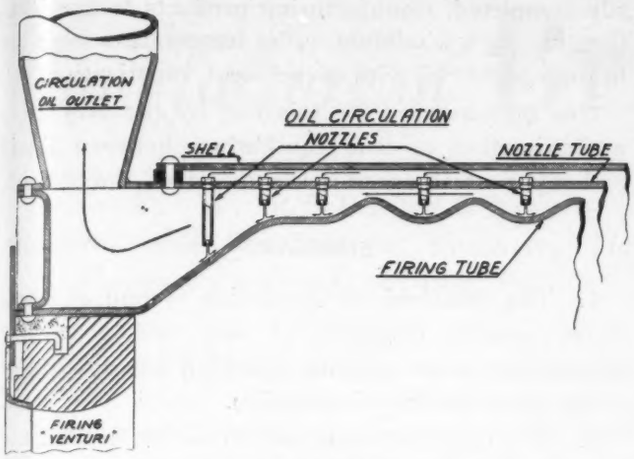

FIGURE 3

Oil Circulation Heater. Cross section of fired end of heater showing nozzles and direction of oil flow. Note mass flow of circulation oil toward outlet at fired end.

of these heating units, based on the percentage of heat input to the oil with respect to the total in terms of the fuel, is approximately 88 per cent even though allowing five per cent for radiation, which, owing to the type of construction of the heaters, is undoubtedly an excessive allowance.

The heat conservation of the air pre-heater in reality reaches the oil to be heated through the medium of the radiant section. It therefore, may be stated that the percentage of the heat transferred in the oil circulation heater itself, is approximately 80 per cent of the total heat value of the fuel burned.

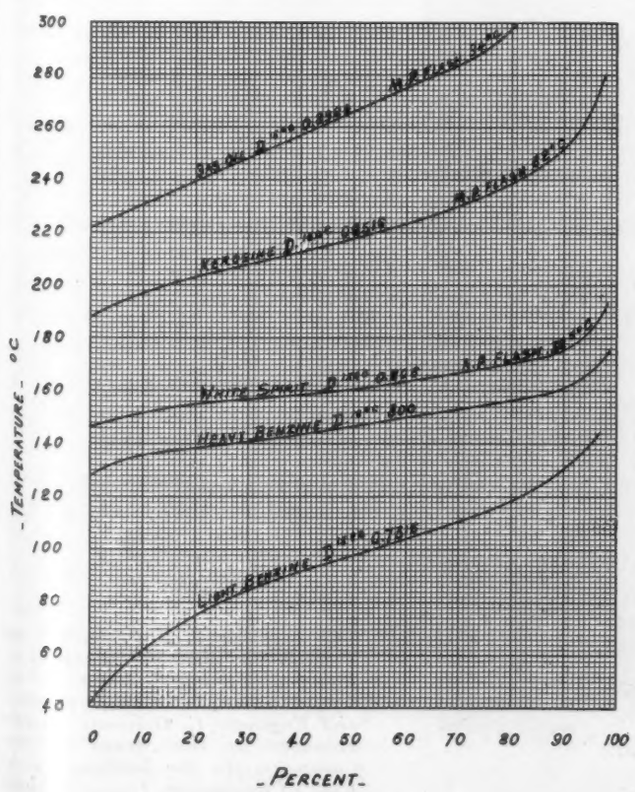

FIGURE 4

Typical Roumanian Products. Curves show products usually demanded by the Roumanian market.

Combustion is provided by means of Peabody mechanical atomizing burners to which air is supplied at a temperature of approximately 325°C. and at a pressure of six inches of water.

Introduction of air heated to such a high temperature very materially increases the flame temperature within the firing tube. Since the rate of transfer of radiant heat increases as the fourth power of the temperature difference, it is evident that very high radiant transfer rates may be attained provided that a means is supplied, as in this case by the oil discharged from the oil circulation nozzles, for rapidly and continuously removing the heat transferred.

Fuel oil is supplied from a dual high pressure Quimby fuel set, circulatory type, at approximately 100°C. temperature and 15 atmospheres pressure.

Spinning combustion is accomplished by introducing heated air into the combustion zone through a wind box shaped like the discharge case of a centrifugal pump, in other words, a volute.

Combustion air is controlled by means of an aerofoil damper which is capable of very accurate adjustment and which has a low pressure drop practically without turbulence.

Manometers are used for maintaining a constant pressure drop across the air dampers.

The combustion system herein described furnishes a flame which never extends, under proper firing conditions, more than half the length of the firing tube or five feet.

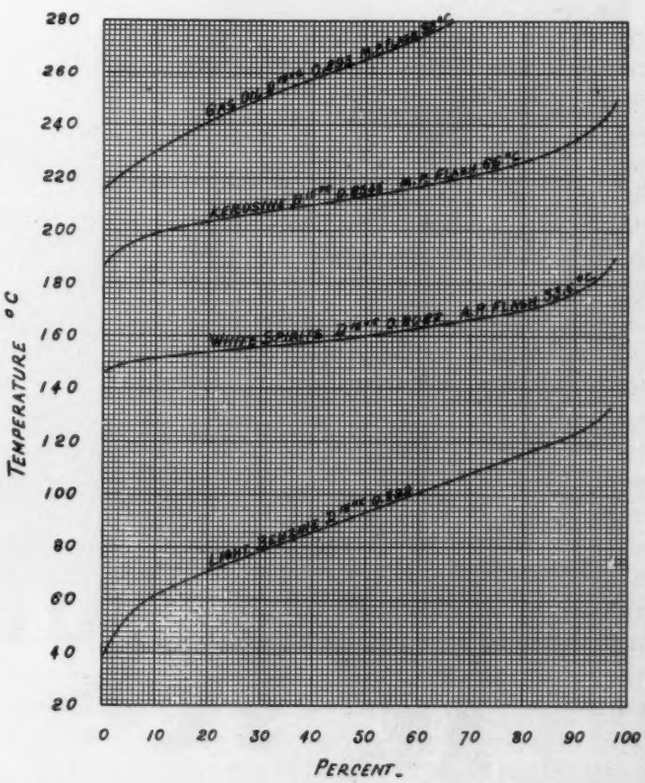

FIGURE 5

Curves showing total elimination of heavy bensine, with gap between end points of the light bensine and initial point of the white spirits.

Owing to the high velocity flow of circulating oil the flue gas temperature at the outlet of the corrugated firing tube, that is 12 feet from the burner, rarely exceeds 750°C.

At a capacity of 5700 barrels per day—vaporizing approximately 50 per cent—the heat transfer rate of the radiant sections is approximately 60,000 B.t.u per square feet per hour.

The fuel release is approximately 69,000 B.t.u. per hour per cubic feet of furnace volume. The transfer rate in the convection sections is approximately 3.3 B.t.u. per square foot of outside surface, per hour, per degree difference.

The fuel rate varies from 1.10 to 1.35 per cent depending on the crude charged.

At the beginning of operations of the unit, when running Piscuri Drader non-paraffinous crude, a normal distilling temperature of 300/310°C. was employed.

Shortly thereafter, it was discovered that the residuum from this crude was extremely corrosive at the above temperatures.

In order to avoid this corrosion, the temperature of the outlet oil from the circulation heaters was gradually reduced so as to escape the corrosive temperature range.

It was found that distillation could be satisfactorily completed, manufacturing products to specification, having a maximum outlet temperature from the heaters of 250°C. with 50 per cent vaporization.

One may account for this fact by the very close approximation to true equilibrium between liquid and vapor which exists in the vaporizer, tower No. 5.

SUMMARY

1. The Stratford oil circulation system of distillation permits operation at very widely varying throughput rates without affecting the quality of products or facility of operation.

2. The combination of oil circulation system and vaporizer permits of distillation at temperatures very closely approximating true equilibrium, thereby providing a means for handling oils sensitive to overheating and thermal decompositions such as pressure distillates, etc.

3. No crude oil containing B.S&M. ever reaches the heaters, thereby providing a very high service factor because cleaning is rarely if ever required.

4. The system permits application of individual reboilers on the bases of separate fractionating towers, thereby making possible maximum yields of products with minimum quantities of tower injection steam. This of course allows the refiner to take advantage of all advantageous price differentials.

The sovereigns of Roumania and Yougoslavia visit the Campina refinery of Steaua Romana. To the left is the sovereign of Yougoslavia and Engineer C. Osiceanu, general manager of the Steaua Romana Company. In the background the King of Roumania, Queen Marioara of Yougoslavia, are accompanied by Dr. Sava, manager of the Campina refinery.

Manufacture of Bright Stock... Present and Future

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PENNSYLVANIA Bright Stock is the term applied to the product obtained by filtering and dewaxing the residue from primary distillation of Pennsylvania crude. In modern practice, crude is charged to a pipe still tower unit and streams of gasoline, kerosene, gas oil, wax distillate and steam refined stock, are removed from various sections of the tower. All of these products except steam refined stock, are completely vaporized and are taken from the tower at points higher than the crude inlet; steam refined stock is not vaporized and is taken from the bottom of the tower as residue. Every effort is made during primary distillation to prevent cracking of any part of the residue. Heat is applied at as high a rate as possible to bring the oil to the temperature of vaporization of the overhead products and the residue is removed from the heated zone and cooled as quickly as possible. Steam is admitted to the bottom of the tower and exerts a partial pressure effect, vaporizing the overhead products at a lower temperature than would be otherwise possible; hence the name "steam refined stock." The residue is filtered through fullers earth to remove coloring matter. It is impossible to say the exact nature of this coloring matter, but the control used in filtering is improvement in color. The filtered oil is dewaxed, either by cold settling or centrifuging, and re-run to remove dilution and to bring the oil to the proper specifications of viscosity and flash. It is then refiltered and the oil has that clear sparkling appearance from which the name "Bright Stock" is derived.

Refinery technicians stand at a cross-roads in the manufacture of bright stock and must make a decision as to which path they shall follow. They must either perfect the processes now in use and give to the public a product of the same quality at a lower cost or institute new processes that improve the quality of the product with increased cost and lower yields.

The question arises, "Are Pennsylvania oils good enough?" If not, by what methods shall we improve them?

Improvement means that the oil shall be more fitted for the purposes for which it is intended. Bright stock is used mainly as a base stock for blending motor oils. Pennsylvania crude yields about 15 per cent bright stock and 7.5 per cent neutrals. Therefore, the chief constituent of motor oils is bright stock, and the purposes of motor oils are the purposes of bright stock. In order to improve bright stocks, we must briefly review the uses of motor oils so that we may have a clear understanding of the problem that confronts us.

The functions of motor oils are that it shall lubricate all of the moving parts and shall seal the piston rings against loss of compression or power from cylinders. In addition to these functions there are a series of "don'ts" to be applied to motor oils which determine whether they are good, bad, or indifferent. My apologies for the following:

The manufacturing mother must admonish her little lubricants in this manner; "Now children, big brother gasoline is very ill and it's going to take all of mother's time nursing him. Mr. X has promised that you may come over and play in his crankcase, provided that you will look after those two dogs of his, Bearing and Journal, and not let them fight. Now whatever you do, don't get too viscous and hold Mr. X's engine when he tries to start it in the morning. You know very well how irritable he is early in the morning. If he can't start that engine, he is likely to send you right back home. Heavens knows what I'd do with you then. And don't get overheated. You tire so fast when you get hot and unless you keep cool and save your strength, you won't be able to keep those dogs apart. The last time that Mr. X had those cheap lubricants tending the dogs, they had a fight and it cost him a lot of money for Dr. Garageman to fix them up. I never saw any children who lose weight the way you do when you are tired. S.A.E. 20, you are looking awfully thin to me already. I wish those cereal companies would make a breakfast food that would keep you as fat and healthy as the children in their advertisements. Don't let that Dilution boy come in and play with you, I don't want you children mixing with him; besides he is always tantalizing Bearing and Journal. I don't like to have you children fight, but if he tries to come in, drive him right out the vent. Don't you dare leave that crankcase. Mr. X was very explicit that you should not go outside and play on the road. Don't go up into Mr. X's com-

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bustion chamber to eat your lunch and leave a lot of carbon lying around up these. Better not go up there at all. Stay right there in the crankcase and I'll send Filter over to clean up after you before Mr. X sees it. Now, children, listen to Mother: Don't oxidize."

And so, gentlemen, there you have them, the things that cause motor oil manufacturers to lie awake at night. Cold weather starting, overheating of motors, dilution, consumption, carbon formation and sludging. There is one characteristic of a motor oil that has a direct bearing on every one of these factors. Viscosity index or the viscosity-temperature relation. Admittedly, viscosity index is an important characteristic of an oil. So much information has been published lately of the effect of viscosity index on the value of oils for motor lubrication that there is very little use in reviewing this data. The natural conclusion would be that in order to improve the quality of a motor oil, we must improve the viscosity index. Yes, to a certain extent. But how much additional cost we are warranted in raising this viscosity index is quite another question. Let us take this viscosity index thing apart and see what makes it work.

The first thing I wish to say is that in Pennsylvania crude we obtain high viscosity index products at no extra cost. The claim is made that it costs $2.00 per barrel to produce Pennsylvania crude and I think you will all agree that at the present price of crude, no premium is being paid for high viscosity index. There seems to be reason back of this thing somehow. Investigators [1] [2] have determined that the usual automobile will start satisfactorily if the proper gasoline is used, if the starter is able to turn the motor at a speed of about 35 R.P.M. and that the usual starter is able to do this if the undiluted oil has a viscosity of less than 50,000 Say. sec. at 0° F. It is also true that, in the usual automobile, lubrication will be maintained safely in the thick film range if the oil has a viscosity as high as 60 Say. sec. at the temperature of operation. This requires a little elaboration. Oil is placed in an automobile to decrease friction. There are two types of lubrication. The first, static or thin film lubrication in which friction is proportional to P.V., (pressure per unit area) times the velocity of one moving body with respect to another. In this type of friction, there is actual metal to metal contact. Second, thick film lubri-

$$\frac{ZN^3}{P},$$

cation, in which friction is proportional to — or viscos-

$$\frac{ZN}{P}$$

ity of oil in centipoises, times speed in R.P.M. divided by pressure per unit area. In this type of friction, there is no metal to metal contact and the friction produced is the internal friction of the oil itself. From this formula — we see that, decrease in viscosity, decrease

$$\frac{ZN}{P}$$

in speed, or increase in pressure all tend to lower the coefficient of friction. There is a limiting value to

$$\frac{ZN}{P}$$

which the function — may be reduced without passing out of the range of thick film friction into that of static friction. With this transition, coefficient of friction increases enormously. Dickenson & Bridgeman[3] give a

$$\frac{ZN}{P} = 20$$

value of — = 20 as a probable safe figure, stating that actual operation is carried on with values as low as 5. Therefore, with the speed and pressure encountered in ordinary operation of automobiles, an oil of 60 Say. sec. viscosity is well within the range of thick film lubrication and a good margin of safety is allowed for overspeeds.

Fifty thousand at 0° F. and 60 at operating temperature. These conditions are most successfully met for ordinary operation by an S.A.E. 30 Pennsylvania motor oil. Where higher temperatures are encountered, an S.A.E. 40 is used and for lower ones an S.A.E. 20. These three grades represent the bulk of automotive oils. Let us take three Pennsylvania oils of 52 sec., 61 sec., and 74 sec. viscosity at 210° F. as representative of each of these three grades and plot their viscosity temperature characteristics on an A.S.T.M. viscosity-temperature chart and then draw a line from the viscosity of the S.A.E. 20 oil at 0° F. to the temperature at which the S.A.E. 40 oil reaches a viscosity of 60 sec. We have plotted the viscosity-temperature characteristics of a theoretical oil which will give the ease of starting of an S.A.E. 20 oil and the high temperature qualities of an S.A.E. 40 oil. This oil would have a viscosity index of about 138. Such an oil is not impossible to make but certainly will be more expensive than present day oils. By inspection of the above curves, we find that at all temperatures above 0° F. the theoretical oil is more viscous than the S.A.E. 20 oil and at all temperatures above 100° F. is more viscous than the S.A.E. 30 oil. Consequently at all operating temperatures this oil will give greater friction loss, which consumes more gasoline and will generate more heat, which must be dissipated by the bearings of the car. I should say that any motorist who obtains satisfactory operation by the use of an S.A.E. 20 or S.A.E. 30 Pennsylvania oil would be foolish to pay the extra cost of manufacture of such an oil as far as value of lubrication he receives. With such an oil, consumption would certainly be cut down and quite possibly the amount of carbon formation, though I am of the opinion this carbon would be of a hard flinty nature. Oxidation of sludging would be lowered with this oil in so far as actual oxidation of the original products are concerned but, as the higher viscosity index products are supposedly more paraffinic than otherwise, and as the paraffines are more susceptible to cracking than other oils, possibly the higher viscosity index oil would crack

easier, form more unsaturates and in turn be oxidized to a greater extent.

These things must be considered very carefully before we raise the cost of manufacture of motor oils and in turn the cost of manufacture of bright stock. A raise in viscosity index of motor oils will not allow automotive designers to make any changes in their cars. The only benefit there can be in increased viscosity index is that the oil will cover a wider range of operating temperature in the field of fluid friction. In order to do this, the oil must be more viscous at the operating temperature at which another oil breaks down and consequently cause increased friction loss and increased heating of bearings.

Now, let us consider the first type of lubrication before mentioned in which friction is proportioned to the pressure velocity constant. In the transition period between the two types of lubrication there is a semi-stable range in which friction is at a minimum. This point is where the real lubricative properties of an oil have their effect. Lubrication and automotive engineers are not vitally interested in conditions where lubrication is perfect except from an academic viewpoint. They are interested in the point at which failure occurs and this point is when friction has progressed well into the static or thin film field. The oil that is valuable is the one that will halt the transition at a semi-stable point and lubricate after there is an actual rupture of the film. In order to do this, an oil must contain products that have a chemical or physical affinity for the metal so that after the film is broken they remain bound to the moving surfaces and prevent interlocking of minute irregularities of the metal. Considerable study of these products have been made by various investigators [4], [5], [6], and a resume of their work seems to indicate the following: lubricating oils consist of two parts, a diluent which gives the oil fluidity, and a portion representing a very small percentage of the oil, perhaps one or two per cent, which gives to the oil its lubricating properties and is independent of the temperature in the field of thin film lubrication.

These compounds are found in the virgin state in Pennsylvania oils and unless they are destroyed by mismanagement of the refining processes, represent the true superiority of Pennsylvania oils over other oils. While manufacturers of oils from other crudes chase that will o' the wisp "viscosity index," let us in Pennsylvania, stick to our business of "lubrication" which brings us back to our subject "bright stock."

These compounds, which give to an oil its lubrication properties, are found in the bright stock. Neutrals give to a lubricating oil its fluidity, or act as a carrier of the lubricants and distribute them over the moving surface. Therefore, extreme care must be taken in the manufacture of bright stock so that no harm comes to these compounds through heavy-handedness on the part of the refiner.

For identification, we shall call the lubricating constituents "polar compounds." Polar compounds are composed of molecules containing groups which are chemically or physically active and groups which are inactive [9]. Therefore, when placed upon a metal surface, the active groups form bonds with the metal and leave the inactive groups free to form a barrier between interlocking irregularities of the metal. A tenacious film adheres to the metal which cannot be wiped away except under extreme conditions. The best example of a similar condition is plush or velvet. The higher the molecular weight of a molecule of a given series, the more bonds will be formed with the metal and consequently, the more tenacious will be the film. For these reasons, Pennsylvania brick stock is made from a residual oil. The polar compounds are the heaviest molecular weight constituents of the oil and cannot be volatilized because the temperature of cracking of these compounds is lower than the temperature at which their vapor pressure is equal to the absolute pressures possible to obtain today in commercial units. In the primary distillation process, extreme care must be used not to heat the oil above the cracking temperature of these products, and steam or vacuum or both are used to vaporize the light overhead products at low temperatures. In the more modern units, automatic controls are used to obtain optimum conditions. There are several indications of cracking that are carefully watched by some refiners. Among them, color of bright stock, precipitation number, and Pensky Martin closed flash. This does not necessarily mean that the steam refined stock with the lightest color is more valuable than others because some Pennsylvania crudes contain more natural coloring matter than others, which has nothing to do with cracking. However, I should say the process that gives the lightest colored stock from a given crude is the better process.

Filtering, the next process after primary distillation, must be carefully controlled. Oils are filtered through fullers earth to remove the natural coloring matter of the oil so that the oil is more pleasing in appearance and to remove any oxidized or polymerized products that are formed during the distillation process. Unfortunately, fullers earth has an affinity for the polar compounds so that filtering cannot be carried past a certain point without damage to the lubricating qualities of the bright stock. To obtain the maximum in appearance and in quality, refiners expend an enormous amount of money and ingenuity. That quality is definitely degraded by filtering too light is shown by the fact that bright stocks of a certain color may be manufactured having the same viscosity as the steam refined stock from which they are made, but if the bright stocks are filtered to a lighter color, there is a decrease in viscosity indicating a loss of high molecular weight, viscous, polar compounds.

Our present method of centrifuging for the removal of wax is our poorest process. We discard about 15 per cent of our product in order to remove four or five

per cent of wax. Paraflow has been one of the greatest boons tendered to refiners of Pennsylvania oils in the last few years in that it enables them to economically market zero pour test oils, providing the blended oil contains a large enough percentage of neutral for the Paraflow to be effective. But for heavier oils such as aircraft oils, Paraflow has no effect. There is certainly no reason for removing wax from an oil, providing solidification of the wax can be prevented. Wax, itself, has a viscosity index of around 170 and it has been shown that the addition of wax definitely raises the viscosity index of an oil and that dewaxing lowers the viscosity index of the oil and that undewaxed oils are more resistant to sludging than dewaxed oils. [7] It is possible that some inhibitor of solidification of wax may be discovered that can be used in bright stocks. It has also been proven that carbon residue of oils may be lowered in proportion to the amount of wax added to them. [8] I am also of the opinion that dewaxing bright stocks by our present methods removes polar compounds along with the small percentage of wax. However, be that as it may, dewaxing will always have to be done as long as inhibitors of crystal growth are not effective in preventing solidification of the oil.

The additional processes of reducing the centrifuged solution of the naphtha used as a diluent to give the proper specific gravity differential between wax and oil, and of refiltering to remove steam haze, or moisture, from the steam, used in the redistillation are as carefully controlled as any of the other processes. Each step in the process of bright stock manufacture is under direct laboratory supervision and certain specifications of physical tests before and after each process are rigidly enforced. These physical tests do not measure directly the value of an oil for lubrication but merely assure the refiner that his products have been processed in the proper manner. I wish to impress the fact that the specifications of a finished product are of no more importance than the specifications of intermediate processes. The finished specifications are very likely an indication of the last process that the oil has been subjected to and to make good bright stock, each process must be as carefully controlled as the last one.

So we see that every process in the refining of bright stock is controlled for the purpose of retaining as near as possible in the virgin state the polar compounds contained in Pennsylvania crudes. These products are found entirely in the bright stock and represent the true value of Pennsylvania oils for lubrication. Pennsylvania oils begin to lubricate where other oils leave off. Let refiners of other crudes improve their viscosity index by solvent methods until they have reached that of Pennsylvania oils. These oils must still be made from overhead bright stocks and their manufacturers will soon find that there is no pot of gold at the end of that rainbow. Any oil will lubricate when conditions of lubrication are perfect but the valuable oil is the one that will prevent failure when conditions are imperfect. Certainly when starting and stopping a motor or when overloading a motor at slow speeds, conditions of lubrication are not perfect and the lubricant must possess some other characteristic besides that of mere viscosity.

Another point I should like to call attention to is that resistivity to oxidation or sludging is more pronounced in residual oils than in overhead oils and the oil that contains the most Pennsylvania bright stock will be the most resistant to sludging.

That the trend in motor lubrication is definitely toward lighter oils is an established fact. This not only means a surplus of bright stock to be disposed of but under the present specifications of bright stock and neutrals, a lessening in the amount of polar compounds contained and a lessening of lubricating qualities. Mabery [5] in his excellent treatise on lubricants, concludes that the best oils are those blended in the proportions that they occur naturally in the crudes. A few simple calculations will prove that the lighter oils do not contain enough bright stock when blended with the neutrals now in common use. Consumption has been given as the reason for lowering the volatility of neutrals to be blended into motor oils. Volatility is certainly a factor in the consumption of motor oils but lowering the volatility past the point where it is effective, when this means a definite loss in lubricating properties, is senseless. Let anyone who believes he is getting consumption through volatilization of light ends of this motor oil make a few simple tests and convince himself. If there is any dilution present, there can have been no evaporation of light ends of the motor oil. If there is no dilution present, a viscosity determination on the oil after sludge and solid matter are removed will quickly determine the loss through evaporation. Another matter I might mention is that dilution increases the viscosity index of an oil faster than any other method I know of.

I predict that the changes that are made in the manufacture of Pennsylvania bright stock in the future will be improvement in our methods of filtering and dewaxing. Extensive study of different clays is being carried on by several companies, and experimental work with treated or activated clay is in process to determine if compounds more suitable for filtering than fullers earth can be found. Also there is the possibility that by the use of selective solvents, we may be able to discontinue the use of fullers earth to remove coloring matter. This statement applies to nothing in particular except to emphasize that the field of solvents is relatively untouched in refining petroleum and that we have no way of knowing until someone tries. In the dewaxing process, solvents more selective between wax and oil than the naphthas used at present are receiving a great amount of attention. While most of these are more expensive than naphthas, efficient methods of recovery will soon discount the additional first cost and if we can recover the additional percentage of bright stock now lost in petroleum, additional cost will be warranted.

I am hopeful that compounds will be discovered which, when added to oils, suppress the formation of wax crystals and allow us to leave a large per cent of the wax in the lubricants. When automotive design reaches such a point that the polar compounds contained in Pennsylvania crude are not able to lubricate in the range of thin film lubrication, because of high pressures encountered, we will add to our lubricants compounds more effective for this purpose. This condition will be met in lubrication of gears but I do not believe that the present materials of construction of bearings will allow much greater speeds and temperatures. The only means we have of telling this is by keeping in close touch with automotive design and keeping pace with their developments.

In conclusion, I wish to sum up the information I have attempted to convey to you in this paper.

I do not know whether internal combustion engines have been built around Pennsylvania oils or whether Mother Nature knew the possibilities and limitations of these engines when she concocted Pennsylvania oils. In any event, she gave to them the proper viscosity index to meet the temperature differential between cold weather starting and high temperature of operation with a minimum of friction loss. She gave to them low volatility so that they stay in the engine when they are placed there and a high resistivity to oxidation and polymerization. And she gave them, in addition, lubricating products that are independent of temperature in the field of thin film lubrication, that will prevent damage to the motor at those times when damage occurs such as starting, stopping, hard pulling on hills, quick acceleration, carelessness, or any time when there is a radical change in operating conditions of the machine. These products are all contained in residual bright stock. The true difference between the lubricating value of Pennsylvania oils and other oils is due to these products. Any improvement in the quality of bright stocks must be directed toward retaining more of these products in the finished oil. Very little can be gained in lubrication of motors by increase in viscosity index above that of virgin Pennsylvania oils. Manufacture of oils from other crudes who are trying to duplicate the quality of Pennsylvania oils by increasing the viscosity index of their oils are on the wrong track because the true superiority of Pennsylvania oil is not due to its high viscosity index. The products that have high viscosity index serve as a carrier to the lubricating products. High viscosity index products are more mobile over a wider range of temperatures and distribute the lubricant more thoroughly than do low viscosity index carriers. That is, when polar compounds are actually torn away from their mooring at the metal surface the more mobile carrier will quickly reform a film to allow fresh polar compounds to bond with the metal. Products that consist of only the carrier without the lubricant cannot hope to serve the purpose when service is needed. Only oils from Pennsylvania crudes can be made from residual oils and oils from overhead distillates cannot contain polar compounds in as high concentration as do residual oils. The trend in motor oils is toward lighter viscosities. Raw products of high quality are delivered to the hands of the refiner of Pennsylvania oils to do with what they may. If he mismanages his refining processes or errs in his recommendation of grade of oil to use for certain purpose, then the blood is on his own hands.

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Treating Natural Gasoline

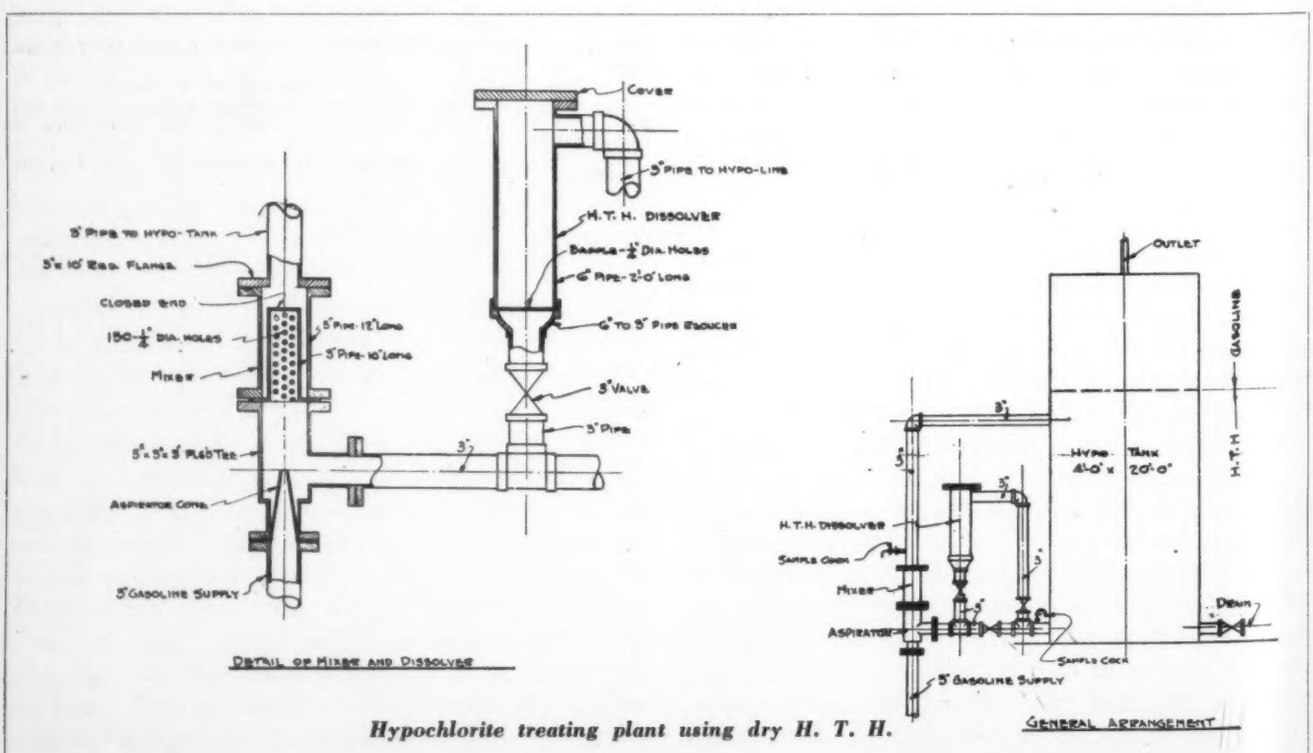
With Various Types of Hypochlorite Solutions

IT is estimated that probably three fourths of the natural gasoline manufactured is treated with some form of chlorine solution. Chlorine is delivered to the plant treating systems in several forms, in cylinders as a liquid, or it is prepared as chlorinated lime (bleaching powders), either standard or that containing a high percentage of available chlorine.

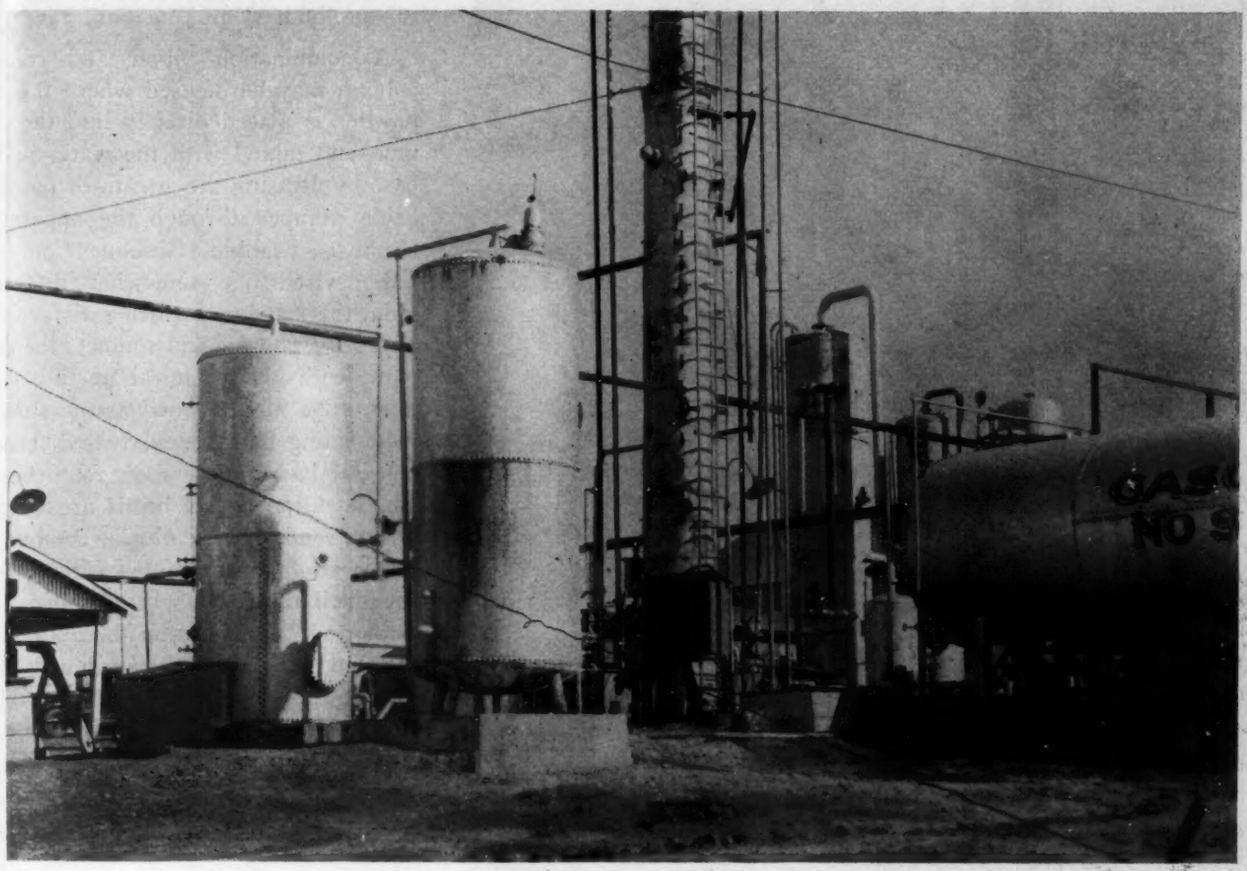
In the sodium hypochlorite process both sodium hydroxide (caustic soda) and liquid chlorine are used. The chemicals are ordinarily mixed in a vertical concrete lined tower, first steaming out the caustic soda from the drums and mixing with the proper amount of water in order that the gravity of the mixture may be reduced to the point desired. After the required caustic soda dilution has been obtained, the liquid chlorine is mixed with the caustic soda and water solution in the tower by introducing it through a submerged line leading from the cylinder.

When this process is being carried out, the temperature of the mixture should be observed carefully, never allowing the rise in temperature to exceed 95° F. High temperatures—above 100 or 110° F.—will cause a break down of the sodium hypochlorite solution into sodium chloride and sodium chlorate, neither being fitted to bring about the treating effects desired. Possibly some operators have been instructed as to what will happen when mixing a batch of sodium hypochlorite if the temperature of the solution is permitted to raise too high, but usually they are instructed to maintain a low temperature and do not understand what will occur if the temperature rises. When the sodium hypochlorite breaks down into sodium chloride, there remains the solution of common salt water, the original from which the two —sodium and chlorine—are derived.

Chlorinated lime, or bleaching powder, has been used extensively, and in fact was used as a treating agent before liquid chlorine was available. Variable results are sometimes obtained when this chemical is used, chiefly because of the instability of the product. The available chlorine content of a good high grade bleaching powder runs around 35 per cent when fresh, but that percentage is reduced rapidly when exposed to the weather. If the drums in which



Hypochlorite treating plant using dry H. T. H.



Treating plant at Amerada Petroleum Corporation's gasoline plant near Seminole, Oklahoma. Caustic tower in middle foreground and hypochlorite tower at left. Dry powder and contactor at left of treating tower.

the chlorinated lime is shipped are not stored in a cool dry warehouse an accelerated deterioriation begins through which the available chlorine in the powders is lost, often disappearing entirely in about 60 days when the temperature runs above 110° F.

Often more drums than needed are ordered and received at the plant, dumped off the truck convenient to the treating equipment and after a short time the results may be unsatisfactory. More and more of the powder is shoveled into the mixing box without securing a good treat on the gasoline. If moisture is permitted to enter the drums, a weak hydrochloric acid is formed, rapidly eating away the drums and hastening the decomposition of the contents. For this reason the drums received should have careful consideration, being always stored away from moisture and excessive heat.

If either of these two methods of treating gasoline with hypochlorite is used, the hydrogen sulfide must be removed before contacting with the treating solution. A dilute solution of caustic soda as a prewash will remove most of the hydrogen sulfide if the gasoline has not been exposed to the oxygen in the air. If this is the case, part of the hydrogen sulfide will be broken down into water and free sulfur, making the gasoline corrosive and it cannot be rendered non-corrosive by treating with hypochlorite. Aeration of natural gasoline cannot occur under normal operating conditions, but if it is manufactured from a gas containing hydrogen sulfide and the gas also contains a high percentage of air, this condition can occur as air oxydizes the hydrogen sulfide to free sulfur and renders the product corrosive.

Many localities in the Mid-Continent in which natural gasoline is manufactured do not produce hydrogen sulfide, and when that compound is not in the gas none of the corrosive features appearing with it are present in the condensate. If hydrogen sulfide is contained in the gasoline, even in minute quantities, a pre-wash of caustic soda should be given to remove it. If it should pass in the gasoline to the hypochlorite treating column or tower, the hydrogen sulfide is broken down into sulfur and water and the free sulfur occurs which causes the dark strips when running the corrosion test. If free sulfur is formed, it cannot be removed with the hypochlorite solution.

When chlorinated lime is used as a treating agent, the operator usually dumps various amounts into the mixing box, handling the powder with a spade or shovel. As the mixing apparatus is sometimes placed in a small building, the fumes from the powder being

Dry powder mixer and contactor column in treating plant of Cromwell-Franklin Gasoline Company's Trosper Park plant in Oklahoma City.

handled causes him to "get out in a hurry," giving as little attention to the mixing as he can get away with. As the chemical is going into solution, water and lime mixed, often the sludge in the bottom of the mixing box is not stirred sufficiently to cause all the available chlorine to pass from the lime to the water. Consequently more of the bleaching powder is removed from the drum than is required, causing the expense of treating to run higher.

When the newer form of chlorine carrier, calcium hypochlorite, or high test hypochlorite is used and since that chemical contains a high percentage of available chlorine, the problem of treating is often simplified. Storing of the unused powder need not have special consideration as it is not subject to the action of the weather. Neither is the sludge formed from the mixture large, and the dry powder may be mixed directly into the column without the preliminary mixing box.

A combination mixer and contact column may be devised where the dry powder is placed directly into the column and mixed with the water in the base by utilizing the stream of gasoline being pumped through the apparatus. Cromwell-Franklin Gasoline Company has devised one somewhat different from the standard, which satisfactorily mixes the powder and contacts the gasoline with the chemical at the same time. The mixing bowl at the side of the treating tank is constructed from a piece of 10-inch pipe about 30 inches in length. Orange peel heads are welded in both ends of the nipple, the one to be placed downward fitted with a short four-inch nipple to which a flange is connected. The head on the upper end is fitted with a nipple machined to a smooth surface. "Ears" are welded beside the opening of the nipple, into which the bolts were placed so that when this opening is closed after charging, a plate with holes corresponding in position to the bolts is placed with a rubber gasket between the plate and the machined end of the nipple. To one side and welded to the body of the bowl is fitted a four-inch collar. As the apparatus was assembled, this bowl was placed in the connections so that by opening or closing plug valves, the bowl can be placed in service or cut out as desired.

When it is evident that a fresh supply of the chlorine carrier should be introduced into the treating system, the plug valves are manipulated so that the bowl is placed out of the stream, the lid removed and the required amount of powder inserted. After placing the powder in the bowl the lid is drawn tight against the gasket and the valves once more opened to place the bowl in service. As the gasoline from the treating pump passes through the bowl, the calcium hypochlorite dissolved in the water and spent solution enters.

Even with the improved methods of contacting, mixing the chemicals and pumping gasoline, it is up to the operator of the apparatus whether a satisfactory and economical treat is obtained. The gasoline of course, must be tested to determine what is to be removed, but once that has been accomplished, the operator must use his head, watching the results as well as the chemicals mixed to secure the desired sweet and non-corrosive product.

Specification for . . .

Chrome Tungsten Steel Castings[1]

BLAINE B. WESTCOTT[2], V. T. MALCOLM[3], and HERBERT HENDERSON[4]

FOREWORD

IN the last few years the refining branch of the petroleum industry has made rapid advancement in the improvement of cracking and other processing methods. This progress has necessitated the employment of constantly increasing temperatures and pressures and has consequently imposed more rigorous demands upon the serviceability of all refinery equipment. It is, therefore, essential that the capabilities and limitations of the equipment be accurately known so that safety of operation can be adequately assured. No precaution is too great when it is possible that a single premature failure may cause loss of life and enormous property damage. Such a potentiality places a very high premium upon an accurate knowledge of the properties of the materials used and the assurance of dependable quality.

Metallurgically the more exacting demands of improved processing methods have been satisfied by the development of stainless steels[5] and, more recently, by the cheaper low chrome steels[6, 7] either with or without other alloying elements. The formulation and adoption of standard specifications framed specifically to satisfy the changing conditions have lagged far behind the practical application of the new alloys and this paper describes an attempt to develop such a specification for chrome tungsten steel castings. It is realized that this specification, which is reproduced here in full as adopted by Gulf Refining Company, represents a rather radical departure from customary practices and is certain, therefore, to cause divergent opinions as to its practicability. As a preliminary to such discussions, it may be stated that its economic workability has been demonstrated in regular foundry operations.

CASTING SPECIFICATIONS

In the design and specification of refinery equipment more consideration is being given to the properties of metals at elevated temperatures[8] and extensive investigations[9, 10] have been conducted to determine their creep resistance. Recently there has been a rather complete coordination[11] of investigational effort to develop a standardized method and equipment for creep testing which involves a high degree of refinement and apparatus of great sensitivity. It is very significant to note that such attention to detail is so generally considered to be necessary in order to assure greater accuracy. It is also of interest to consider briefly the nature of the products to which this exceptionally accurate data will be applied.

Refinery installations are largely made up of various rolled, forged or cast steel products. The latter, in the form of valves, pipe fittings, return bends, headers, etc., comprise a sizeable portion of these installations and, since they are subjected to the same severe operating conditions as the rolled or forged steel products from which the remainder of the equipment is built up, it is equally essential that their properties and quality be as definitely known.

It is hardly necessary to point out that rolled and forged products are purchased by specifications which require that physical properties and general quality shall be determined by testing of the finished products. Data so obtained can be confidently used for design and constructional purposes. An entirely different situation exists, however, with respect to castings. Casting specifications make no provision for the determination of physical properties of the metal that actually goes into service, the limiting requirements being invariably intended to apply to test bars which are occasionally cast attached to heavier castings, but more generally are cast at-

[1]The specification included in this article was developed by the Engineering Department of Gulf Refining Company from a cooperative investigation by Gulf Research and Development Corporation and Chapman Valve Manufacturing Company.

[2]Engineer of Tests, Gulf Research and Development Corporation, Pittsburgh, Pa.

[3]Metallurgical Engineer, Chapman Valve Manufacturing Company, Indian Orchard, Mass.

[4]Manager, Engineering and Construction Department, Gulf Refining Company, Pittsburgh, Pa.

[5]The 18-8 Iron-Chromium-Nickel Alloy with Particular Reference to its Characteristics for Cracking Coil Service. H. D. Newell, *Proc. Div. of Ref., A. P. I.*, 28 (April, 1931).

[6]The Selection of Materials for High Pressure and High Temperature Work in Oil Refineries. V. T. Malcolm, *Oil and Gas Jour.*, 31, No. 21, 14 (1932).

[7]Properties of Low-carbon Medium-chromium Steels of the Air-hardening Type. E. C. Wright and P. F. Mumma; *Tech. Pub. No.* 496-C94, *A.I.M.E.*, Feb., 1933.

[8]Some Long-Time Tension Tests of Steels at Elevated Temperatures. J. J. Kanter and L. W. Spring; *Proc. Am. Soc. Test. Mat.*, 30 (1), 110 (1930).

[9]Flow Characteristics of Special Fe-Ni-Cr Alloys and Some Steels at Elevated Temperatures. H. J. French, W. Kahlbaum, and A. A. Peterson; *Bur. of Stand. Jour. of Res.*, 5, 125 (1930).

[10]Creep Characteristics of Metals at Elevated Temperatures. A. E. White and C. L. Cark; *Trans. Am. Soc. Steel Treat.*, 21 (1933).

[11]Development and Trend in Ferrous Alloys for High Temperature Service. F. N. Speller; *Proc. 13th Annual Meeting, A.P.I.*, 1932.

tached to separate blocks. The relationship between the properties of metal in castings and in separately cast test blocks may be variable for a number of obvious reasons so that the user has been forced to hope that the properties of the former approximated those of the latter. Allowance is made for any existant differences by applying a large factor of safety which could be more aptly termed a factor of ignorance.

Separately cast test bars are used as a control check on melting operations and they are admirably suited to fulfill this need of the foundry. They are invariably cast with large risers, i. e., under conditions ideally suited to produce sound metal and their properties represent, therefore, the maximum attainable under any given conditions. Under existing specifications they are quite generally used, as previously pointed out, to represent the physical properties of the castings. The purchaser is not particularly interested in the results that can be attained under exceptionally favorable casting conditions, but is vitally concerned with the properties of the castings on the performance of which so much depends. As a source for this information test bars are practically worthless and the inclusion of physical property requirements in ordinary casting specifications is largely futile since, by common acceptance, they are not applicable to the castings.

It has been repeatedly asserted[12] by the foundry industry that it is impractical to judge quality by results of physical tests of specimens taken from the castings. The only safeguards which have been freely offered have been destructive and hydrostatic tests, neither of which provides information which may be translated in a quantitative manner into terms of serviceability and, the application of the above mentioned factor of safety. These empirical methods of testing and inspection are no longer considered adequate by the purchaser when applied to castings for high temperature and high pressure service as attested by the growing tendency towards radiographic inspection of each individual casting. Adherence to and advocacy of these past practices will inevitably build up a prejudice against the use of castings where it is possible to substitute a product fabricated by some other method that is better adapted to impart structural uniformity. Already, forged and welded products are rapidly displacing castings, thereby making it vitally important to the foundry industry to exert every effort to improve the quality of castings so that they may successfully comply with more rigorous tests and methods of inspection. The problem is mutual to producer and consumer and there is no desire on the part of the latter to impose unduly severe limitations on the former.

[12]Purchase Requirements for Steel Castings, With Notes on Physical Properties in Test Bars and in Commercial Castings. R. A. Bull; Symposium on Steel Castings at Joint Meeting of American Foundrymen's Association and American Society for Testing Materials, Atlantic City, N. J., June 21, 1932.

[13]Production of Electric Steel for Castings. George Batty; Eleventh Annual Convention of American Society for Steel Treating, Cleveland, Ohio, Sept., 1929.

[14]Deoxidation and Mold Conditions on the Tensile Properties of Carbon Steel Castings. J. V. McCrae and R. L. Dowdell; Twelfth Annual Convention of American Society for Steel Treating, Chicago, Ill., Sept., 1930.

[15]Notes on the Design of Steel Castings. F. A. Lorenz, Jr.; Symposium on Steel Castings at Joint Meetings of American Foundrymen's Association and American Society for Testing Materials, Atlantic City, N. J., June 21, 1932.

DUCTILITY IN CASTINGS

One of the most essential properties in a metal for high temperature and high pressure service is ductility. A ductile metal will give warning of impending failure by deformation while a brittle metal will fail suddenly without deformation and hence without warning. Lack of ductility, i.e., brittleness, has been one of the most serious faults of castings. Brittleness in castings may result from any one or a combination of causes; it may be an inherent property of a particular metal, it may be due to melting practice[13, 14], it may be caused by internal defects and general unsoundness, it may be caused by improper heat treatment or in some steels it can result from slow cooling from operating temperatures (temper brittleness). Present discussion is concerned only with brittleness which results from unsoundness in the castings and from improper heat treatment since careful selection of materials will eliminate the other causes.

EFFECTS OF IMPERFECTIONS ON PHYSICAL PROPERTIES

The soundness of metal in castings is influenced by a number of factors which, for brevity, may be grouped under the two heads, design and foundry practice. It is quite necessary that there be close cooperation between the designer and foundryman if satisfactory castings are to be assured.[15] Fortunately, the castings that are exposed to the most severe conditions of refinery operations are, in general, relatively simple and, therefore, do not present any unusually difficult foundry problems so that the task of increasing soundness is primarily concerned with the foundry practice. Metal in a casting may be unsound to an appreciable degree without materially affecting the yield point or tensile strength, but only slight flaws are sufficient to reduce greatly the elongation and reduction of area even though the metal has been so conditioned by heat treatment that it has high ductility. Furthermore, this pseudo-brittleness persists at elevated temperatures so that such castings are unsuited to resist the fatigue action engendered by the cyclic temperature and pressure changes of still operations.

The soundness of metal in any section of a casting is influenced by its relation to other sections of the casting and its location, i.e., whether in the cope or drag. It is entirely unreasonable to expect uniformly perfect soundness throughout a casting, but, on the other hand, it is wholly reasonable to expect sufficient soundness in any part of a casting to impart a moderate amount of ductility as a safeguard against

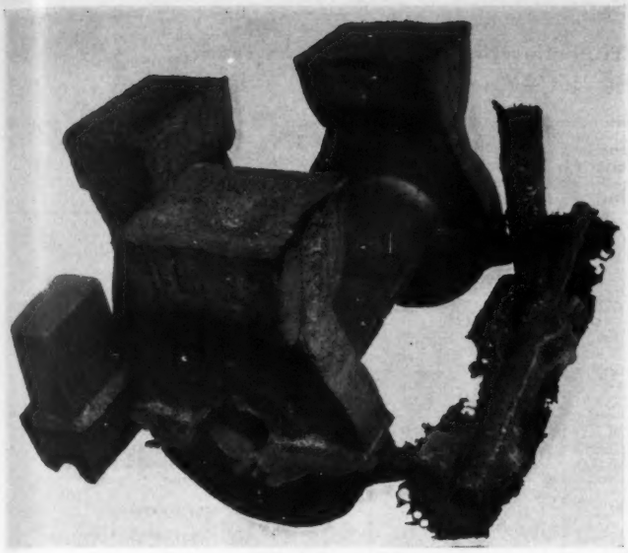


FIGURE 1

Cast chrome tungsten steel flanged tee with test bar attached to cap flange, before removal of gate, sprues and risers.

a totally brittle failure. There is enough evidence to warrant the belief that this objective can be reached without any sizeable penalty upon the economy of foundry operations.

The influence of internal flaws on the physical properties of metal in castings is illustrated by the results given in Table 1. The castings upon which these tests were made were 4x4x4 inches, 1350 pounds, flanged tees, pictured in Figure 1 before the removal of gate, sprues and risers. The castings were from three different heats of steel and were given different heat treatments. In every case, failure of test specimens from the castings to exhibit normal ductility could be definitely attributed to readily discernible internal flaws of varying magnitude. There was only one instance, however, when the flaw was large enough to effect a noticeable reduction in tensile strength. Although the body sections were only about one inch thick while the flange sections were three inches thick there were but slight differences in physical properties. The use of chills on casting 3 increased the yield strength of the body metal greatly and also that of the cap flange, but to much lesser degree; tensile strengths were not greatly increased. The properties of the test bars attached to a flange of castings 1, 3, 4 and 5 afford an interesting comparison, both with each other and with the castings to which they were attached. In all cases they had slightly greater ductility because of their greater freedom from internal flaws, but there was exceptionally good correlation in the other properties. From the results given in Table 1 it is significant to note the fact that a fair degree of ductility can be obtained from test bars taken from practically any section of the castings provided that they are reasonably sound.

BRITTLENESS INDUCED BY HEAT TREATMENT

Very often otherwise satisfactory castings are rendered brittle and unfit for service by improper heat treatment. This condition has frequently been found in the heavier castings of the five per cent chrome steels probably because, in most foundries, it has been easiest to assume that these steels behave the

TABLE 1

Effect of Internal Flaws on the Physical Properties of Specimens from Chrome Tungsten Steel Castings

Casting No.	Location of Test Bar	Yield Point (lb./sq. in.)	Tensile Strength (lb./sq. in.)	Elongation (% in 2 in.)	Reduction of Area (%)	Brinell Hardness	REMARKS
1	flange, drag	90,200	107,700	14.0	28.5	212	small flaws — normalize 1750°F., water quench 1625°F., draw 1250°F.
	flange, drag	90,800	109,600	21.5	48.6	223	
	flange, cope	88,100	89,400	2.0	0.0	241	failure at large flaw
	flange, cope	88,100	107,900	7.5	9.0	241	failure at large flaw
	body, drag	90,200	110,500	10.0	11.1	...	failure at large flaw
	test bar on flange	91,700	117,400	20.5	50.9	241	1⅛ in. section
2	flange, drag	92,200	103,300	19.0	36.7	229	normalize 1750°F., normalize 1625°F., draw 1250°F.
	flange, drag	91,000	113,200	16.0	33.1	229	
	flange, cope	86,300	111,500	19.0	41.3	229	
	flange, cope	85,400	100,500	4.0	1.4	229	failure at flaws
3	flange, drag	56,300	91,000	17.0	25.1	179	some flaws — chill on back of cap flange in drag and on the body in both cope and drag.
	flange, drag	48,800	90,500	15.0	27.5	179	small flaws
	flange, cope	59,200	93,500	14.0	18.1	179	small flaws
	flange, cope	59,200	90,300	12.0	....	187	large flaws
	body, drag	72,500	104,000	18.0	25.1	207	
	body, drag	72,300	104,300	20.0	26.1	207	normalize 1650°F., 6 hr
	body, cope	73,600	103,400	18.0	26.8	207	small flaws — draw 1300°F., 6 hr.
	body, cope	72,500	104,600	19.0	29.5	207	
	cap flange, cope	63,400	98,600	22.0	42.5	187	
	cap flange, cope	67,800	98,500	14.5	22.3	207	small flaws
	cap flange, drag	66,200	99,200	15.5	27.5	187	small flaws
	cap flange, drag	64,100	99,500	19.0	35.4	187	
	test bar on flange	59,100	95,700	21.0	50.6	187	2½ in. section
	test bar on flange	61,400	94,900	20.0	51.8	187	
4	flange	88,000	112,700	15.5	35.7	229	normalize 1750°F., normalize 1600°F., draw 1250°F.
	test bar on flange	76,600	105,200	20.0	43.4	217	1⅜ in. section
	test bar on flange	78,500	104,700	17.0	35.1	205	
5	flange	90,000	112,500	16.0	32.5	229	normalize 1750°F., normalize 1600°F., draw 1250°F.
	test bar on flange	93,300	114,700	17.0	38.8	229	2½ in. section

TABLE 2

Effect of Heat Treatment on Physical Properties of Test Specimens from Chrome Tungsten Steel Castings[1]

Casting No.	Location of Test Bar	Heat Treatment[2]	Yield Point (lb./sq. in.)	Tensile Strength (lb./sq. in.)	Elongation (% in 2 in.)	Reduction of Area (%)	Brinell Hardness	REMARKS
Test bar 1		N 1750°F., D 1250°F.	83,800	108,600	20.5	46.0	229	cast separate
Test bar 2		N 1750°F., N 1650°F., D 1250°F.	91,900	119,500	20.0	45.7	241	cast separate
6	cope	N 1750°F., D 1250°F.	48,800	92,600	11.0	9.6	187	crystalline fracture
	drag	N 1750°F., N 1750°F., D 1250°F.	101,700	126,700	4.5	3.8	269	whole casting treated
	drag	N 1750°F., N 1750°F., D 1250°F.	96,800	117,100	17.0	40.3	248	small bar treated
7	test bar on flange	N 1750°F., D 1250°F.	85,500	116,700	20.5	53.1	255	
	cope	N 1750°F., D 1250°F.	80,800	108,800	5.5	7.0	...	crystalline fracture
	drag	N 1750°F., D 1250°F.	88,200	142,300	4.0	3.5	311	crystalline fracture
	cope	N 1750°F., N 1850°F., D 1250°F.	98,100	98,100	2.0	0.8	248	whole casting treated
	drag	N 1750°F., OQ 1700°F., D 1250°F.	98,100	122,300	20.5	47.5	241	small bar treated
8	cope	N 1750°F., N 1850°F., D 1250°F.	108,300	124,700	3.5	3.9	269	crystalline fracture
	drag	N 1750°F., N 1850°F., D 1250°F.	104,800	120,800	4.0	3.9	255	
	drag	N 1750°F., N 1850°F., D 1250°F.	107,900	115,200	2.0	1.4	269	crystalline fracture
1	test bar on flange	N 1750°F., SH WQ 1625°F., D 1250°F.	91,700	117,400	20.5	50.9	241	silky star fracture
	drag	N 1750°F., SH WQ 1625°F., D 1250°F.	90,200	107,700	14.0	28.5	212	silky fracture, small flaws
	drag	N 1750°F., SH WQ 1625°F., D 1250°F.	90,800	109,600	21.5	48.6	223	silky fracture
9	test bar on flange	N 1750°F., SN 1700°F., D 1250°F.	55,100	97,000	24.0	50.9	183	silky star fracture
		N 1750°F., SN 1700°F., D 1250°F.	71,600	106,100	17.5	23.1	207	flaw, { 3 in. x 3 in. x 3 in.,
		N 1750°F., SN 1700°F., D 1250°F.	72,100	105,900	20.0	40.3	223	{ 1350 lb. tee
5	test bar on flange	N 1750°F., SN 1600°F., D 1250°F.	93,300	114,700	17.0	38.8	229	silky fracture
		N 1750°F., SN 1600°F., D 1250°F.	90,000	112,500	16.0	32.5	229	silky fracture

[1]All specimens were taken from the flanges of the tees.
[2]N = normalize, D = draw, SH = slow heat, SN = slow normalize, WQ = water quench.

same as straight carbon or low chrome nickel steels. In many foundries it is often expedient to treat castings of greatly different sections at one time under conditions which cannot be suited simultaneously to both light and heavy sections. It is dangerous to allow expediency to dictate the heat treatment of castings for high temperature and high pressure service as shown by the results in Table 2. Castings 6, 7 and 8 were normalized with 10 tons of miscellaneous castings, according to regular practice, for three hours at 1750°F. and drawn for a like period at 1250°F. This treatment resulted in ideal conditioning of the test bars either cast separately or attached to the castings. The test specimens for the determination of the physical properties of the castings were taken only from the flanges so that maximum soundness would be assured and only those results were considered where no flaws in the metal were visible. Therefore, it may be safely assumed that the lack of ductility was chargeable to a lack of efficacy of heat treatment. The microstructure of test bar 1 (Figure 2) when compared with that of the body of casting 7 (Figure 3), having the same sectional thickness, proves without doubt that the brittleness was caused by the ineffectiveness of the heat treatment and indicates the degree of uncertainty which can be in-

FIGURE 2
Structure of separately cast test bar 1 after regular normalize at 1750°F. and draw at 1250°F. Nital etch, magnification 100x.

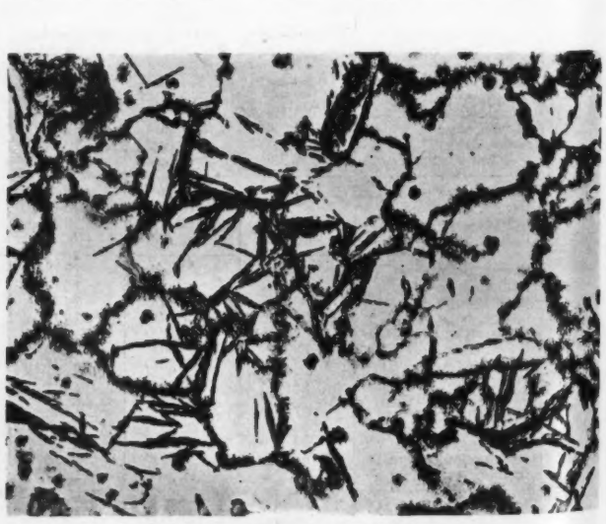


FIGURE 3
Structure in body of casting 1 after regular normalize at 1750°F. and draw at 1250°F. Compare with Figure 2. Nital etch, magnification 100x.

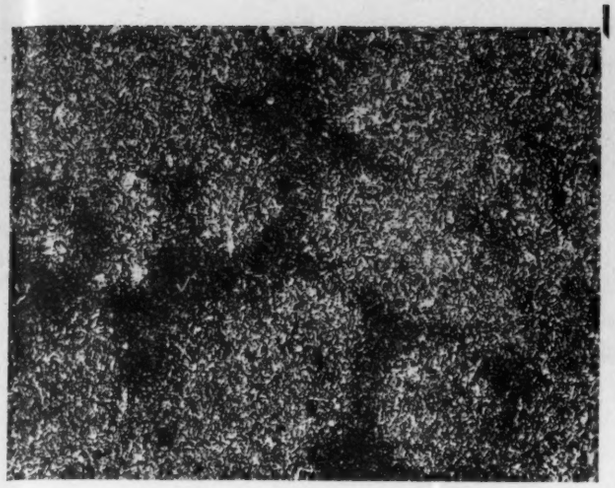


FIGURE 4

Structure of test bar attached to flange of casting 5 after modified heat treatment. Nital etch, magnification 100x.

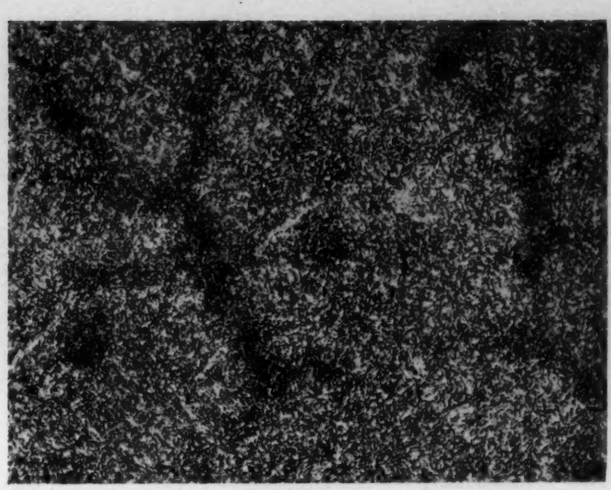


FIGURE 5

Structure of flange of casting 5 after modified heat treatment. Compare with Figure 4. Nital etch, magnification 100x.

jected by reliance upon test bar results. The structural characteristics of castings 6 and 7, as judged by the results of physical tests, were not improved by a second identical normalizing treatment, but a second treatment on small pieces cut from the flanges produced ductility comparable to that of the test bars (see Table 2). These results are indicative not only of the effect of mass in heat treating, but of the sluggishness in response to heat treatment of the five per cent chrome steels.

In contrast to the above results are those obtained by a second normalizing treatment of castings 1, 9 and 5. The second normalize differed from the first principally in the use of a greatly retarded rate of heating; the soaking period at the normalizing temperature being the same. It is clear from Table 2 that exceedingly satisfactory ductility was imparted to both test bars and castings. Casting 5 affords an exceptionally interesting example of nearly perfect correlation between the casting and its attached test bar both in physical properties and microstructure as is apparent from Figures 4 and 5. In this case the sectional dimension of the attached test bar was equivalent to that of the flange.

INSPECTION OF CASTINGS

Proceeding with the knowledge that casting quality cannot be determined by means of separately cast test blocks it is necessary to consider the various tests that can be utilized for this purpose. They may be grouped into two classes; destructive tests that can be economically applied to smaller castings and non-destructive tests which must of necessity be used for the larger and more expensive castings.

In the first group of tests sufficient consideration has already been given to the importance of the determination of the physical properties of the castings. A valuable adjunct in the detection of interior

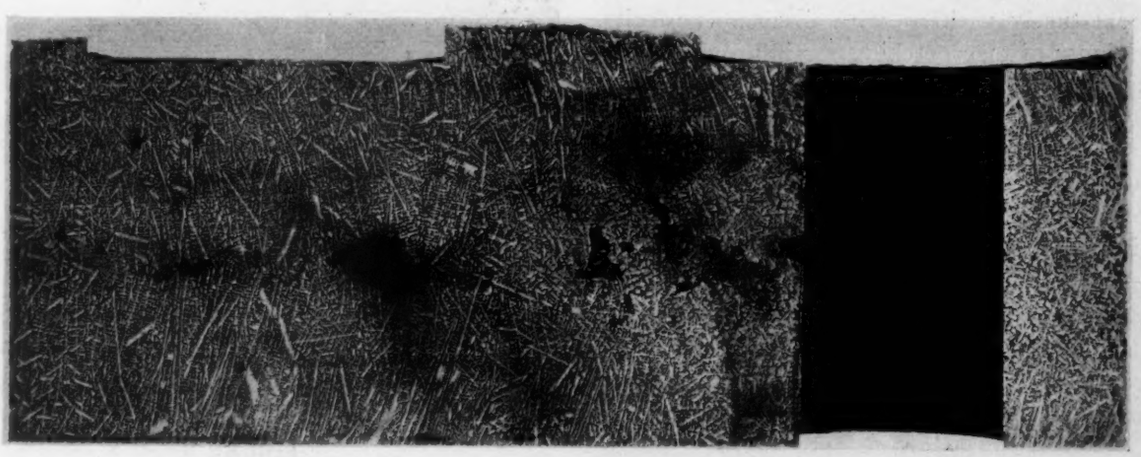


FIGURE 6

Macroetched section from a flange of a tee showing shrink cavities and a crack. This fitting was purchased in the open market after passing the usual inspection tests.

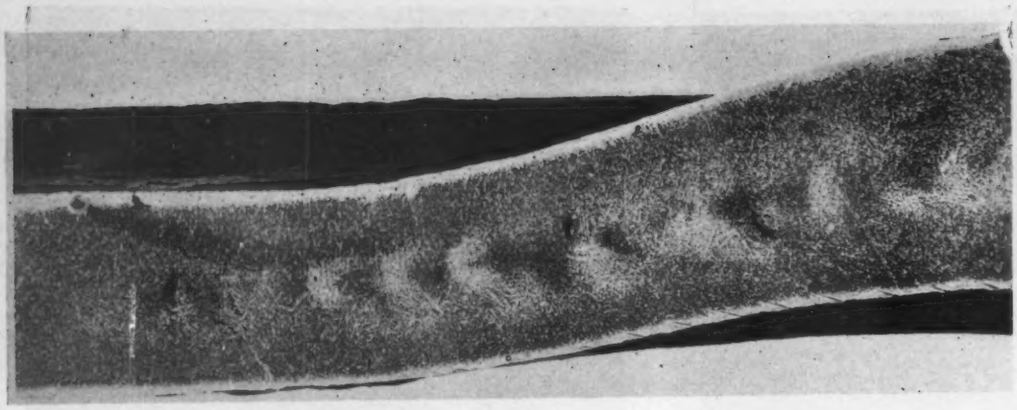


FIGURE 7—(Left)
Macroetched section from the body of a flanged tee showing hot tears caused by strains set up during solidification and cooling of the metal.

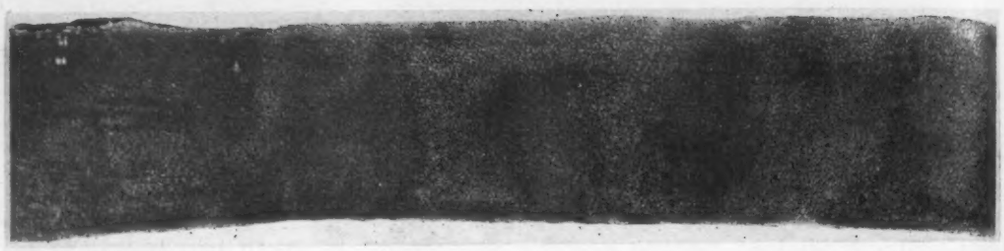


FIGURE 8—(Right)
Macroetched section from the body of a flanged tee showin satisfactory soundness resulting from the use of chills.

unsoundness is supplied by macroetching of sections taken from critical points in the castings. This test is in common use[16] for the inspection of high quality rolled steel and forgings[17] and seems destined to wider application in the inspection of castings. It is extremely advantageous because of its simplicity and inexpensiveness and it can be used very effectively if carried out under standardized conditions by experienced observers. This is illustrated by Figure 6 which pictures the defects revealed by macroetching of a section of a flanged tee that was purchased in the open market and had successfully passed a hydrostatic test at 7000 pounds for a rated working pressure of 1350 pounds. Extensive shrink cavities extending into a bolt hole are clearly visible as well as a crack extending from the seating surface more than half way through the flange. Had this tee been placed in service it would certainly have failed prematurely perhaps with disastrous results. The usefulness of macroetching for improving foundry practice and promoting greater soundness is shown by Figures 7 and 8. In Figure 7 hot tears or casting strains in the body section of a flanged tee can be seen while Figure 8 indicates how effectively these defects were eliminated by chills on the body section in both cope and drag.

A common type of destructive test that is quite extensively used in casting inspection is the drop ball impact test. The value of this test is questionable because of the numerous uncontrollable factors which are introduced, the lack of standardization in its use, and because it does not provide any quantitative measure of casting quality. As an inspection tool for castings intended for high temperature and high pressure service it has but little value in comparison with the more informative tests which have been previously considered.

Of the non-destructive methods of inspection the best known and most used is the hydrostatic test. Because of the general recognition of the absolute necessity for this test and its practically universal use, it need not be given any further consideration except to note that it does not measure any property of a casting other than its ability to withstand a definite static fluid pressure.

In an earlier section, the importance of effective heat treatment was pointed out, especially in relation to the conditioning of castings with heavy sections.

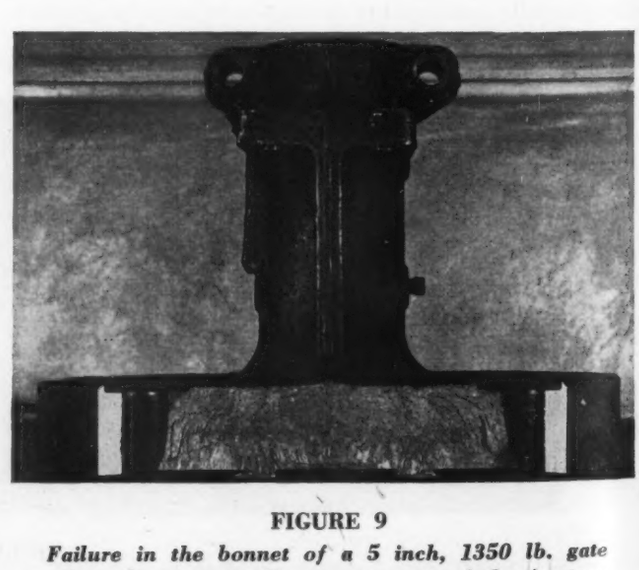


FIGURE 9
Failure in the bonnet of a 5 inch, 1350 lb. gate valve. Coarse crystalline appearance of the fracture indicates that failure was caused by improper heat treatment.

[16]Development and Application of Macro-Etching. H. G. Keshian; *Trans. Am. Soc. Steel Treat.;* 21, 289, 1933.

[17]Investigation of Bolt Steels. V. T. Malcolm and John Juppenlatz; *Trans. Am. Soc. Steel Treat.;* Feb., 1927.

The examination of metallographic structure affords the most reliable means for evaluating the results of heat treating operations and fortunately it may be so carried out as to place it in the class of non-destructive tests. Some purchasers require annealing lugs to be attached to large and expensive castings to be used after heat treatment to indicate the structure of the metal in the casting. The value of this test is largely determined by the size of the lug as compared to the heaviest section of the casting, and if the two are practically equal and the length of the lug is at least twice its sectional dimension it will have a metallographic structure similar to that of the casting. It is better, however, to make this examination by the removal of a small section from a portion of the heaviest part of the casting in such a way as not to affect its usefulness. Such an inspection

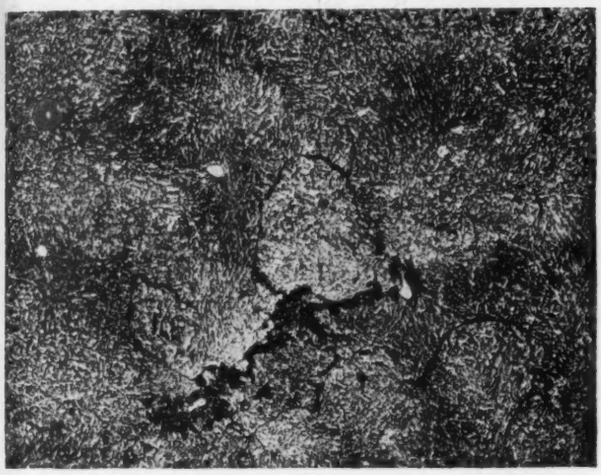


FIGURE 10

Microstructure of the bonnet of a 5 inch, 1350 lb. gate valve. The metal was exceedingly brittle because of the segregation of carbide at the grain boundaries. Etched with nital, magnification 100x.

would have prevented the premature failure in the bonnet of a five inch, 1350 pound valve shown in Figure 9. It can be seen from this photograph that the casting was absolutely sound throughout the entire section. Test specimens prepared from the metal directly adjacent to the fracture were also sound and had the physical properties given in Table 3, which includes those of the separately cast test block from the same heat.

TABLE 3

Physical Properties of Test Specimens from the Bonnet of a Five Inch, 1350 Pound Valve

Property	Valve Bonnet[1]	Test Block
Yield point (lb./sq. in.)	128,000	98,000
Tensile strength (lb./sq. in.)	141,200	120,300
Elongation (per cent in 2 in.)	1.3	18.0
Reduction of area (per cent)	2.6	38.0
Brinell hardness	326	

[1]Averages of two specimens.

[18]An X-ray Inspection of a Steel Casting. W. P. Davey; *General Electric Review*, Jan., 1915.
[19]X-ray Tests as Applied to Problems of the Steel Foundry. H. H. Lester; *Trans. Am. Soc. Steel Treat.*, 6, No. 5, 1924.
[20]Discussion on X-ray Metallography. V. T. Malcolm; *Proc. Am. Soc. Test. Mat.*, 25, Part 1, 1924.

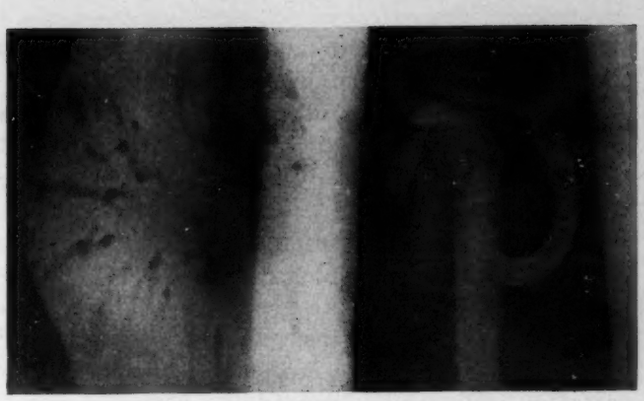


FIGURE 11

X-Ray photograph showing gas or slag pockets in the body of a 3 in., 1350 lb. gate valve.

The microstructure of the metal in the bonnet, shown in Figure 10, is manifestly that of steel in a brittle condition after incomplete heat treatment and unable to withstand the strains set up in tightening the flange bolts in spite of its unusually high strength. It is impossible to overemphasize the importance of this method of inspection for alloy steel castings.

Although not yet in general use there is not the slightest doubt that radiographic examination will eventually be recognized as the most valuable non-destructive test for castings where positive assurance of soundness is essential. Either the X-ray or gamma ray method may be used for the detection of internal flaws in castings. The X-ray method is the older of the two,[18] but its adoption in practice has been retarded because it requires costly equipment of such bulk that it is not readily portable. It has found its greatest use thus far as a method for studying foundry problems[19, 20] and for the inspection of welds

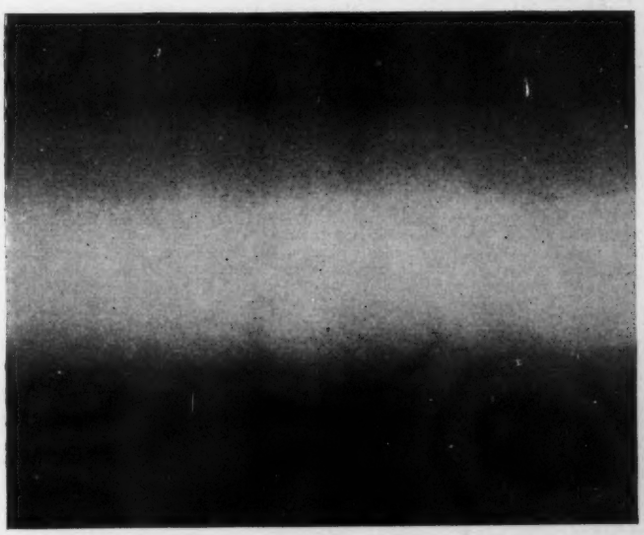


FIGURE 12

X-Ray photograph showing large internal crack in the body of a 3 in., 1350 lb. gate valve.

in pressure vessels[21] and similar equipment[22] at the point of manufacture and, because of its lack of flexibility, probably will continue to be used only to this limited extent. The maximum metal thickness that can be examined practically by X-rays does not exceed four inches.

Gamma ray radiography for the inspection of castings offers several advantages over the X-ray method, principal of which are greater flexibility, lower cost and ability to inspect heavier sections.[23] Coupled with the above is the added fact that the necessary equipment is rugged and perfectly mobile thus making possible its adoption for wider application in casting inspection than can be envisioned for the X-ray method.

There is apparently little to choose between the two methods in regard to sensitivity, either being capable of detecting flaws of a size not less than two per cent of the thickness of the section. One condition that is retarding the progress of radiographic inspection is the lack of a means for indicating the results. Photographic recording is time consuming and, therefore, is but poorly suited for the inspection of large numbers of castings. The perfection of a means whereby the presence of flaws would be indicated without the necessity for making a permanent record would furnish an impetus to this method of inspection that is now lacking. Examples of flaws that are detectable by X-ray examination of castings are given by Figures 11 and 12 taken from the bodies of 3 inch, 1350 pound valves; the former shows numerous gas or slag pockets while the latter reveals the presence of a large internal crack. With comparatively frequent proof of the existence of such serious internal defects in castings, the need for the more general use of radiographic inspection is apparent.

[21]The Application of Fusion Welding to Pressure Vessels. J. C. Hodge; *Jour. Am. Weld. Soc.*, October, 1930.
[22]Non-Destructive testing of Welds by Means of the Stethoscope and X-Ray. A. B. Kinzel, C. O. Burgess and A. R. Lytle; *Jour. Am. Weld. Soc.*, Vol. 8, No. 9, Sept., 1929.
[23]Radiography by the Use of Gamma Rays. Robert F. Mehl, Gilbert E. Doan, and Charles S. Barrett. Twelfth Annual Convention, *Am. Soc. Steel Treat.*, Chicago, Ill., Sept., 1930.

SUMMARY

It is daily becoming more plainly evident to those closely connected with the manufacture and application of castings to refinery service that the present standard casting specifications are inadequate from every standpoint and that if beneficial use is to be made of the data on the properties of metals at elevated temperatures, which are being assembled with such a high degree of precision, it will be necessary to use more rigid methods of inspection which can be made wholly practicable only by the closest cooperation between the producers and users of the castings. Thousands of castings are giving satisfactory service today, but failures from other than normal causes are of sufficient frequency to point out the necessity for greater uniformity of quality if they are not to be largely displaced by forged and welded equipment. Excellent alloys are available which are particularly suited for refining operations either because of their unusually high creep strength or corrosion resistance or both, but, on account of their high cost, they cannot be used in castings with economy unless so fabricated as to assure a normal service life. Such assurance can only be had by the knowledge that the castings are integrally sound and properly heat treated. The accompanying specification is designed for these purposes and is indicative of the mutual benefits that accompany a thorough cooperation between the manufacturer and user.

ACKNOWLEDGEMENTS

The authors express their appreciation to Mr. Thomas Maher, president of Chapman Valve Manufacturing Company, whose interest made the investigational work connected with the development of this specification possible. Acknowledgement is also due the several members of the staffs of Chapman Valve Manufacturing Company and Gulf Research and Development Corporation for their aid in the carrying out the investigation.

STANDARD SPECIFICATION FOR CHROME TUNGSTEN STEEL CASTINGS

G. R. Co., P-105, R6., April 5, 1933.

1. Material

1-A—This specification governs the purchase of steel castings, containing approximately 5 per cent chromium and 1 per cent tungsten, intended for use in petroleum refining operations under corrosive conditions at elevated temperatures and high pressures.

1-B—This specification applies to valves, fittings, rough and machined castings fabricated from steel of the approximate composition given in 1-A.

1-C—The vendor shall be fully responsible to the purchaser for the quality of the castings irrespective of the source from which the rough castings are obtained.

2. Patent Infringement

2-A—The vendor shall defend any and all patent infringement suits in which the purchaser is made a defendant by virtue of the use of material covered by this specification and shall defray all costs and expenses incurred by the purchaser in the defense of such lawsuits. Further, the vendor shall pay all costs, expenses, claims, royalties, damages and penalties awarded the plaintiff as a result of any such litigation.

2-B—The purchaser may be represented in any or all patent infringement suits by counsel of its own selection. The costs of such representation will be borne by the purchaser.

3. Design and Patterns

3-A—The design of all castings purchased to this specification shall be approved by the purchaser.

3-B—The castings may be made from patterns furnished either by the vendor or purchaser as specified by order.

3-C—Patterns furnished by the purchaser shall not be altered by the vendor without written approval by the purchaser.

4. Manufacture

4-A—The steel shall be made by the electric furnace process. Upon written authority of the purchaser steel for castings furnished to this specification may be made by the open hearth process. Unless such written authority is obtained castings fabricated from steel made by any process other than the electric furnace process shall be rejected.

4-B—The foundry in which the castings are made shall be approved by the purchaser.

5. Chemical Properties and Tests

5-A—The steel shall conform in chemical composition to the requirements in Table 1.

TABLE 1

Chemical Composition of Chrome Tungsten Steel Castings

Constituent	Per cent Minimum	Per cent Maximum	Desired
Carbon	0.150	0.250	0.200
Manganese	0.300	0.500	0.450
Phosphorus		0.050	
Sulphur		0.050	
Silicon	0.400	0.600	0.500
Chromium	4.500	6.500	6.000
Tungsten	0.800	1.250	1.000

5-B—An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Table 1, 5-A. This analysis shall be made from drillings taken at least ¼-inch beneath the surface of a test ingot poured from the melt and the results shall conform to the requirements specified in Table 1, 5-A and shall be reported to the purchaser in duplicate.

5-C—The purchaser may make chemical analyses as desired from test specimens or castings. The results of analyses thus made shall conform to the requirements specified in Table 1, 5-A. Samples for analysis shall be taken not less than ¼-inch beneath the surface, except in the case of castings which are too thin.

6. Heat Treatment

6-A—The castings shall be heat treated to provide the physical properties specified in Table 3, 8-A and/or Table 5, 9-D.

6-B—The heat treating operations shall be so conducted as to insure substantial uniformity of properties in all castings.

6-C—No castings shall be heat treated by quenching in any liquid medium.

7. Physical Tests

7-A—The static physical properties shall be determined by means of test specimens machined to conform to the dimensions given in Figure 1 and Table 2. The largest type specimen it is possible to prepare from the section to be tested shall be used. The ends of tension test specimens shall be of a form to fit the holders of the testing machine in such a way that the load is axial.

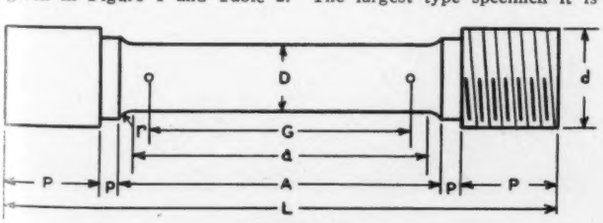


FIGURE 1
Tension Test Specimen

TABLE 2
Dimensions for Tension Test Specimens

TYPE OF SPECIMEN	DIMENSION [IN.] D	G	a	r	A	p	P	L	d
1	0.505	2	2¼	NOT LESS THAN ⅛	THE GAGE LENGTH, PARALLEL SECTION AND FILLETS SHALL BE AS SHOWN, BUT THE ENDS MAY BE SHAPED TO FIT THE HOLDERS OF THE TESTING MACHINE IN SUCH A WAY THAT THE LOAD SHALL BE AXIAL.				
2	0.437	2	2¼						
3	0.357	1.4	1⅝						

7-B—The yield point shall be determined either by the drop of the beam or the retardation of the indicating dial hand of the testing machine or shall be taken as the load necessary to cause an elongation of 0.01 inch in a gage length of 2 inches measured with an extensometer or by a pair of dividers using the gage marks punched in the specimen to determine the elongation. The speed of the cross head of the testing machine shall not exceed ⅛ inch per minute within the yield point and the tensile strength shall be determined at a speed not to exceed one inch per minute.

7-C—If any test specimen shows defective machining or develops flaws another specimen prepared from the same casting or test block may be substituted. The nature of any flaws developed, when considered characteristic, shall be taken into consideration when determining the acceptability of the material.

7-D—If any test specimen fails to equal the defined minimum physical properties a second test may be made on specimens prepared from another casting or test block from the same heat.

7-E—Castings which are rejected because of failure to conform to the specified minimum physical properties may be given a second heat treatment, but shall thereafter be subject to the same inspection and tests by which they were originally rejected.

7-F—The purchaser may select, at his own expense, any desired number of castings for physical tests.

7-G—Failure of castings, selected and tested as specified, to conform to the various requirements as to physical properties shall cause rejection of the entire lot of castings.

7-H—Whenever possible the physical properties shall be determined on the rough castings or test bars after heat treatment, but before any machining operations have been performed. Unless otherwise agreed upon by the purchaser and vendor, no machining operations shall be performed until the lot of castings have conformed to the requirements as to physical properties.

8. Physical Properties of Castings

8-A—For castings weighing less than 150 pounds the physical properties of the steel shall be determined by test specimens taken from the castings. The physical properties of test specimens thus prepared shall be equal to or exceed the minimum limits in Table 3.

TABLE 3

Minimum Limits for Physical Properties of Test Specimens Prepared from Castings

Property	Minimum Limit
Yield point (lb./sq. in.)	75,000
Tensile strength (lb./sq. in.)	100,000
Elongation (per cent in 2 in.)	12.0
Reduction of Area (per cent)	20.0
Brinell Hardness (range)	180 to 240

9. Physical Properties of Test Bars

9-A—For castings weighing more than 150 pounds the physical properties of the steel shall be determined from test bars cast attached to the castings where practicable. Test bars shall remain attached to their respective castings until presented for inspection after the completion of all heat treating operations. At least one casting from each heat of metal used in filling the purchaser's order shall have a test bar attached. Each casting weighing 500 pounds or more shall have a test bar attached.

9-B—If the design of a casting is such that it is impracticable to attach a test bar, upon approval by the purchaser, the physical properties shall be determined from test bars cast attached to separate blocks. All separately cast test blocks shall be heat treated with the castings which they represent. At least one such test block

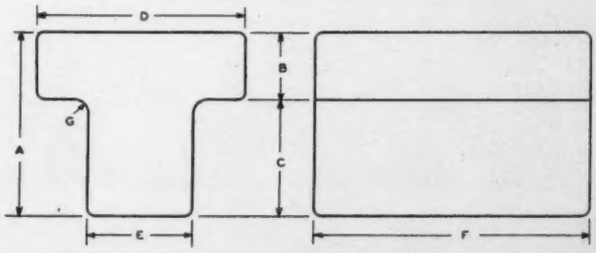


FIGURE 2

FIGURE 3
This structure is acceptable.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

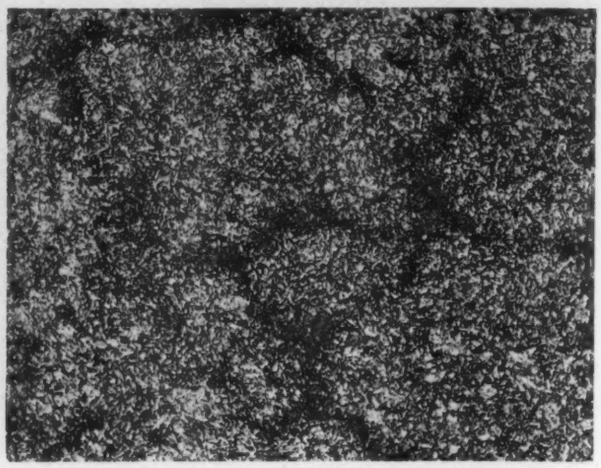


FIGURE 6
This structure is acceptable.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

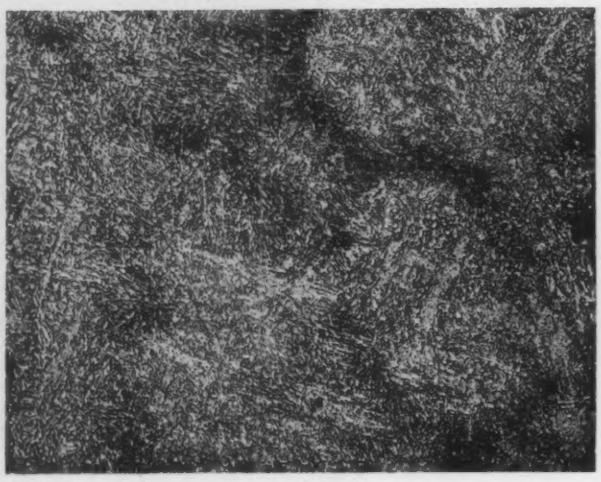


FIGURE 4
This structure is acceptable.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

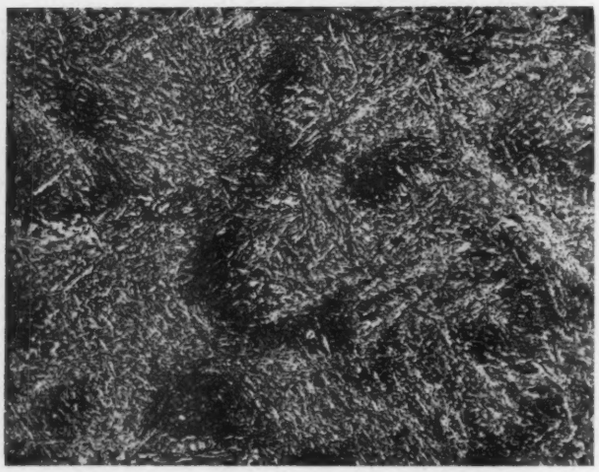


FIGURE 7
This structure is acceptable.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

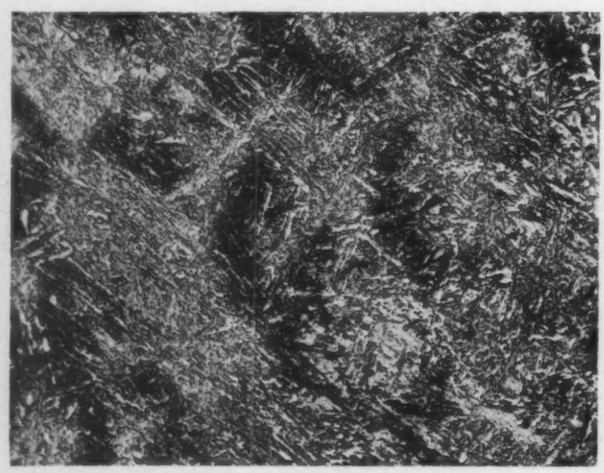


FIGURE 5
This structure is acceptable.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

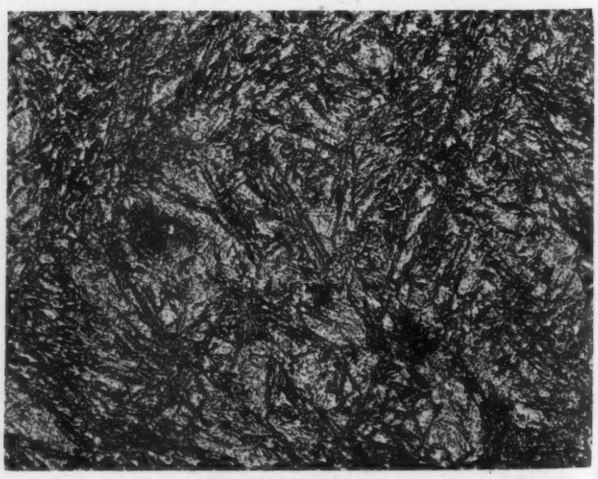


FIGURE 8
This structure is acceptable.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

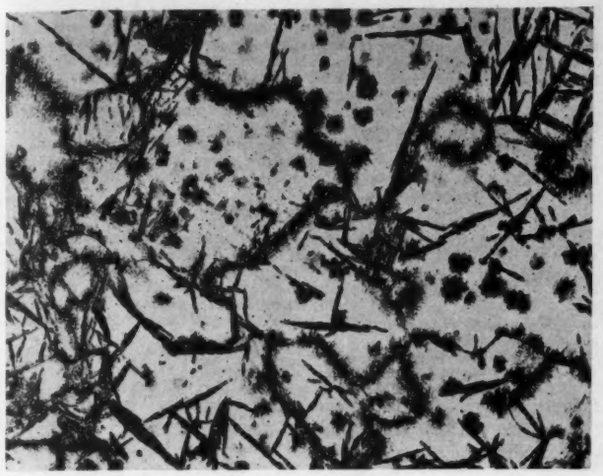


FIGURE 9
This structure is not acceptable and casting shall be rejected.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

FIGURE 12
This structure is not acceptable and casting shall be rejected.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

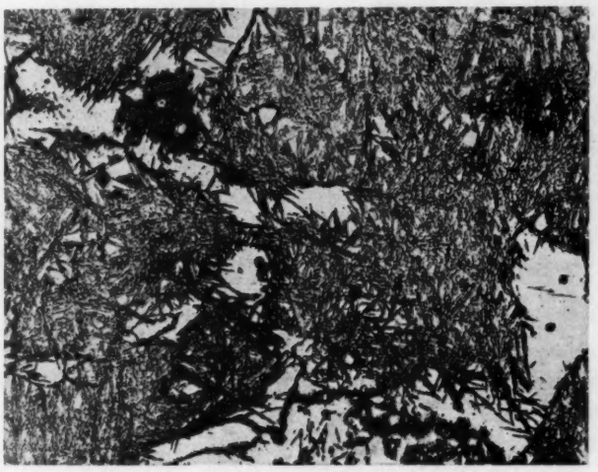


FIGURE 10
This structure is not acceptable and casting shall be rejected.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

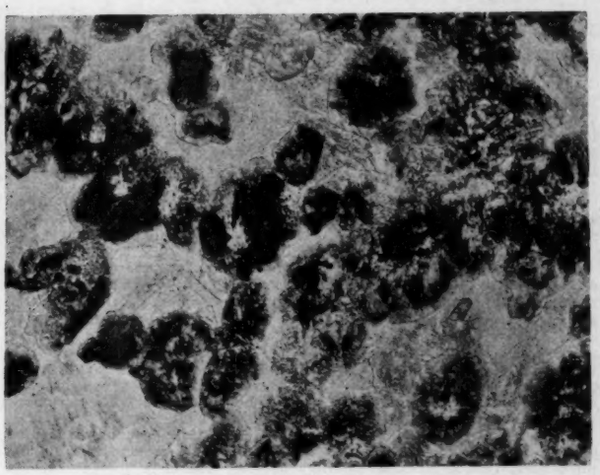


FIGURE 13
This structure is not acceptable and casting shall be rejected.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

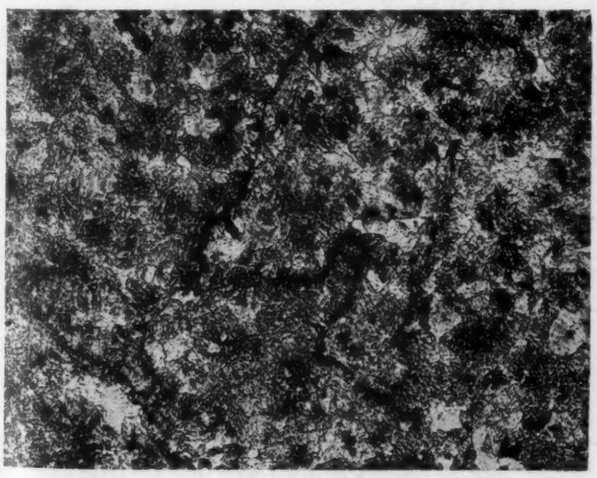


FIGURE 11
This structure is not acceptable and casting shall be rejected.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

FIGURE 14
This structure is not acceptable and casting shall be rejected.
Magnification 100x.
Etchant, 3% nitric acid in methyl alcohol.

shall be cast from the middle of each heat of metal used in filling the purchaser's order.

9-C—All test blocks either cast attached to castings or cast separately shall be of the type illustrated in Figure 2. The dimensions of test blocks shall be in accordance with Table 4; the size of the test block to be used in any particular case shall be determined from dimension E in Table 4 which shall agree as closely as possible with the heaviest section of the casting of which the test block is representative.

9-D—The physical properties of test specimens prepared from

TABLE 4
Dimensions of Test Blocks

NO.	DIMENSION [IN.]						
	A	B	C	D	E	F	G
1	5 1/2	2	3 1/2	4	1	8	3/8
2	5 1/2	2	3 1/2	4 1/2	1 1/2	8	3/8
3	5 1/2	2	3 1/2	5	2	8	3/8
4	5 1/2	2	3 1/2	5 1/2	2 1/2	8	3/8
5	5 1/2	2	3 1/2	6	3	8	3/8
6	5 1/2	2	3 1/2	6 1/2	3 1/2	8	3/8

test blocks shall be equal to or exceed the minimum limits for the respective sizes of test bars given in Table 5.

TABLE 5
Minimum Limits for Physical Properties of Test Specimens Prepared from Test Blocks

Property	Test Bar No.	Minimum Limit 1, 2	3, 4	5, 6
Yield Point (lb./sq. in.)		85,000	80,000	75,000
Tensile Strength (lb./sq. in.)		110,000	100,000	95,000
Elongation (per cent in 2 in.)		18.0	16.0	15.0
Reduction of Area (per cent)		40.0	35.0	30.0
Brinell Hardness (range)			180 to 240	

9-E—The use of chills on any section of any test block shall cause rejection of the entire lot of castings without reccurse to retests of any nature.

10. Destructive Tests

10-A—At the option of the purchaser one or more rough castings may be selected for destructive impact test. Castings broken in this manner shall be free from interior defects such as tears, shrinks, shrinkage cracks, slag, gas and sand pockets, evidence of core shifts or any other defects which, in the judgment of the purchaser, render them unsuitable for the service intended. The fracture surfaces of the metal shall be finely crystalline or silky in appearance and shall not exhibit a coarsely crystalline brittle fracture. The castings shall be deformed before fracture to an extent sufficient to indicate satisfactory toughness and ductility.

10-B—If any casting used in the destructive test develops imperfections of such magnitude as to preclude its acceptance by the purchaser, two additional castings may be similarly tested. Failure of these castings to successfully pass this test shall result in rejection of the entire lot.

11. Sectional and Macroetching Tests

11-A—At the option of the purchaser one or more rough castings may be selected for sectioning and/or macroetching tests; any castings selected for this purpose shall be cut in any designated locations. Macroetching of exposed sections shall be carried out by immersion of the section in the following solution for one hour at a temperature of 180°F.:

concentrated hydrochloric acid	—38% by volume
concentrated sulfuric acid	—12% by volume
water	—50% by volume

Any section or sections so exposed, either etched or unetched shall be free from defects such as tears, shrinks, shrinkage cracks, slag, gas and sand pockets, or imperfections of any other nature which, in the judgment of the purchaser render them unfit for the service intended.

11-B—If any casting examined in this manner reveals imperfections of such magnitude that they are unacceptable to the purchaser two additional castings may be similarly examined. In the event that one of these castings is also found to be unacceptable the entire lot shall be rejected.

11-C—In the event of a disagreement between the representative of the purchaser and vendor as to the interpretation of macroetching tests, rejection or acceptance shall be based on the result of a conference between representatives of the purchaser and vendor mutually considered to be competent by experience to correctly judge the significance of the evidence.

12. Metallographic Structure

12-A—The metallographic structure of the castings after heat treatment shall be determined and judged to be satisfactory for the service intended by the purchaser. For this purpose specimens may be prepared, at the option of the purchaser, from castings used for physical tests, test blocks cast attached to castings or cast separately, or sections may be taken from any designated castings in such a manner that the usefulness of the castings is not impaired.

12-B—Whenever possible the metallographic structure shall be determined on the rough castings after heat treatment, but before any machining operations have been performed. Unless otherwise agreed upon by the purchaser and vendor, no machining operations shall be performed until the lot of castings has successfully met the requirements as to metallographic structure.

12-C—Metallographic structures similar to those illustrated by Figures 3 to 8 inclusive shall be judged as satisfactory.

12-D—Metallographic structures similar to those illustrated by Figures 9 to 14 inclusive shall be judged unsatisfactory and the lot of castings shall be rejected.

12-E—Any casting or lot of castings rejected because of unsatisfactory metallographic structure may be given a second heat treatment. They shall thereupon be subjected to the same structural requirements as previously.

13. Hydrostatic Tests

13-A—All castings shall be tested hydrostatically after machining to a pressure that is at least four times the rated working pressure or to any definite pressure specified in the order. When desired, kerosene may be substituted for water in making pressure tests. Castings so tested shall show no leaks after five minutes at the testing pressure while being sharply struck with a machinist's hammer.

13-B—All unmachined castings purchased shall be tested hydrostatically as described in 13-A.

13-C—All castings that show leaks in the hydrostatic test shall be rejected without any provision for retesting.

14. Repairing of Defects

14-A—No surface defects or leaks developed by the hydrostatic test shall be repaired by peening or plugging.

14-B—No castings shall be treated at any time during the fabricating operations with a material of any nature which is intended to reduce their natural porosity.

14-C—When approved by the purchaser, defects which do not impair the strength of the castings may be repaired by the electric welding method using coated welding rod of the same alloy composition as the castings or of high chromium content. The defects shall be cleaned out to solid metal and approved by the purchaser before welding.

14-D—All castings shall be heat treated after being repaired by electric welding.

15. Radiographic Inspection

15-A—At the option of the purchaser and at his expense any or all castings furnished in accordance with this specification may be examined by either the X-ray or gamma-ray method of inspection. All castings thus examined shall, in the judgment of the purchaser, be free of internal defects of any nature of such a magnitude as to render them unfit for the service intended.

15-B—Common defects found in any two or more castings inspected radiographically shall be considered characteristic of that particular type of casting and shall result in rejection of the entire lot of castings of that type.

15-C—In the event of a disagreement between the representative of the purchaser and the vendor as to the interpretation of the results of radiographic inspection, rejection or acceptance shall be based on the result of a conference between representatives of purchaser and vendor mutually considered to be competent by experience to correctly judge the significance of the evidence.

16 Workmanship and Finish

16-A—The castings shall conform substantially to the shapes and sizes indicated by the patterns and/or drawings submitted by the purchaser.

16-B—All castings shall be free of dirt or scale on all exposed surfaces.

16-C—The castings shall be free from all injurious surface defects such as cold laps, seams, porousness, blisters, blow holes, sand or slag pockets, cracks, shrinks or other defects of any nature and shall not show evidence of warpage or core shift.

16-D—The castings shall be machined as specified by the order and all machined surfaces shall be free from injurious defects of any nature and shall have a finish which, in the judgment of the purchaser, renders them fit for the service intended.

17. Marking

17-A—All castings furnished to this specification shall be plainly and durably marked with the vendor's name or trade mark, the heat number, the letters C T and for valves and fittings the rated working pressure and temperature.

18. Inspection and Rejection

18-A—All castings furnished to this specification are subject to inspection during the process of manufacture. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the vendor's works which concern the manufacture of the castings ordered. The vendor shall afford the inspector, without charge, all reasonable facilities to satisfy him that the castings are being furnished in accordance with this specification.

18-B—The purchaser may elect to use any or all of the various tests included in this specification to determine the acceptability of any casting or lot of castings.

18-C—Inspection shall be made at the plant of the vendor prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

18-D—At the option of the purchaser, castings selected for physical tests, sectional and macrographic tests, metallographic examination or radiographic investigation may be shipped to the Research Laboratory of the purchaser for these tests.

18-E—Failure of the castings selected for test purposes to conform to any of the tests made in accordance with this specification shall constitute sufficient cause for the rejection of the entire lot of castings.

18-F—Inspection does not relieve the vendor of the responsibility of furnishing castings of satisfactory quality and any castings that give unsatisfactory service because of faulty material or workmanship shall be replaced by the vendor at no cost to the purchaser.

18-G—The purchaser shall bear the cost of castings selected by the purchaser for test purposes. The cost of all castings used for retest purposes from any cause whatever shall be borne by the vendor, but the number so used shall not exceed 3 per cent of the total number ordered.

Synthetic Lubricating Oils from Gaseous Olefine Hydrocarbons

A. D. PETROV, L. I. ANTZUZ and E. N. POZHILTZEVA

From Zhurnal Prikladnoi Khimii (J. appl. Chem. U. S. S. R.): 5, 790-796, (1932)

THE accompanying translation from the Journal of Applied Chemistry, U. S. S. R., embodies considerable interesting information dealing with the preparation of synthetic lubricating oils from gaseous olefine hydrocarbons. The work described was carried out on a laboratory scale, using ethylene concentrate containing 20 to 33 per cent olefines, the balance being composed mainly of methane and hydrogen. The yields secured are discussed as are the characteristics of the synthesized products.

Translation is by A. A. Boehtlingk.

RESOURCES of gaseous olefine hydrocarbons derived from petroleum and coal are very large. According to G. Egloff[1] the production of olefines from petroleum and from coal in 1929 was as shown in Table 1.

These resources have a tendency to increase considerably in the near future because of the proposed development in the cracking of natural gases, vapor phase cracking of petroleum and the intended development of the low temperature carbonization industry.

The yield of olefines from the high temperature carbonization in Germany is now estimated to be as high as 150,000 tons basing only on the excess of gas after the deduction of the consumption of coke oven plants and of the gas transmitted through long distance pipe lines and taking into consideration the possible development of the latter market.[2]

Taking into consideration the proposed developments of the coking and low temperature carbonization industries in Russia (which should produce 42,000,000 and 40,000,000 tons respectively only in the Kuznetzk basin) together with the proposed developments in vapor phase cracking of petroleum which should also take care of cracking of primary tars, the problem of dealing with a large quantity of olefines will arise. It is clear that these resources are too large for a complete utilization in the alcohol, glycol, etc., industries. As a matter of fact the gases produced in the proposed coking and low temperature carbonization plants to be built in the Ural-Kuznetzk basin will yield yearly about 300,000 tons of olefines. On the other hand it should be noted that Russia does not have large resources of crude oils high in lubricating oils.[3] Thus a condensation of olefines to light products and lubricating oils, the demand for which is very high, appears to be a very important technological problem, particularly because of the fact that the preparation of ethyl alcohol from ethylene is too expensive. An investigation of the thermal condensation of gaseous olefines under atmospheric and elevated pressures to motor fuel mainly of the gasoline type was recently concluded by I. Z. Ivanov in the High Presure Laboratory of the Academy of Science (Petrograd).[4] The problem discussed in this paper covers the catalytic conversion of olefines in the presence of $AlCl_3$ mainly to synthetic lubricating oils. Although the first investigation in connection with the conversion of olefines into lubricating oils in the presence of $AlCl_3$ was undertaken by Friedel and Crafts in 1877, the first attempt to supply the industry with necesary data is found in the recent research carried out by A. Nash[5] and F. Sullivan et al.[6]. Attention is drawn[7] to a review on the above subject which appeared in a magazine.

In our experiments, now being described, we used an "ethylene concentrate" supplied by the plant "Neftegaz." This concentrate contained 20 to 33 per cent olefines, the balance being composed mainly of methane and hydrogen. The catalyst $AlCl_3$, ground into a fine powder, was charged into the autoclave

TABLE 1

The volume of lower olefines in gases. (in cubic feet)

Origin of Gases	Production in 1929	Ethylene	Propylene	Butylene
Cracked gases.....	250,000,000	15,000,000	20,000,000	10,000,000
Coke oven gases.....	540,000,000	14,580,000	.....	.....
Carburated water gas....	255,000,000	17,085,000	.....	.....

[1]J. Phys. Chem. :35, 1825-1903 (1931); Chem. Abstracts: 25, 4843 (1931).
[2]Chemiker Ztg. :55, 826 (1931).
[3]Paigachev. Neftyanoe Khozyaistvo: (1931), No. 6.
[4]I. Z. Ivanov. Zhurnal Prikladnoi Khimii (J. appl. Chem. U. S. S. R.): Reference not given and it can not be found.
[5]J. Inst. Petroleum Techn. :16, 830-69 (1930); C. A. :25, 1664 (1931).
[6]Ind. Eng. Chem. :23, 604-11 (1931); C. A. :25, 3476 (1931).
[7]A. D. Petrov. Khimiya Tverdogo Topliva: 2, No. 11-12, 108-120 (1931).

together with petroleum ether of 45 to 70°C. (113 to 158°F.) boiling point, using equal parts of both ingredients. The concentrate was as a rule transferred from a bomb into the closed autoclave under a pressure of 40 to 60 atmospheres. After the drop of the pressure in the autoclave to 30 atmospheres, which took place after varying periods depending upon the temperature of the experiment, the capacity of the autoclave, etc., the remaining gas was let out from the autoclave without emptying it and a fresh portion of the concentrate was injected in the autoclave. We succeeded in collecting about ten fold the amount of the condensate using one catalyst, this requiring about 12 days when working at room temperature.

The velocity of the reaction was fluctuating, depending on the mode of operation (thus for example stirring accelerated the reaction considerably) and particularly on the temperature. It should also be noted that the condensation is greatly improved when changing the concentrate each day, this increasing the partial concentration of the olefines in the autoclave. Consequently, when working on a commercial scale, it would appear advisable to effect a preliminary concentration of the olefines. Furthermore we thought it worth while to try a condensation of the olefines under circulation, because we noticed that the catalyst became covered with oils whereby its activity was impaired. The temperature used in the reaction of condensation had also an effect on the character and the yield of the condensation products as well as on the ratio of the individual products obtained. In our investigations we prepared condensates at room temperature and at 100°C. (212°F.). The experiments were carried out in a rotating Bergius autoclave placed on a shaking machine and in 2-3 liter stationary autoclaves. The total capacity of the apparatus used reached 12 liters which made it possible to collect in a comparatively short time more than 2 kilograms of the condensate prepared at room temperature and about one kilogram from experiments carried out at 100°C. (212°F).

EXPERIMENTS AT ROOM TEMPERATURE

(Data supplied by L. I. Antzus.)

After the completion of the condensation process the contents of each autoclave were discharged, the condensate washed with water, dried, and the solvent distilled off (petroleum ether). The free oil which was separated in these operations will be called "A". There was also another oil, "B", which was held by the catalyst and which was recovered by adding water to the residue left in the autoclave. The separated oil, "B", was then taken up with ether, dried and distilled. We obtained a total of over 2 kilograms of oil and used about 1.5 kilograms for our investigations.

In the above distillation 1 kilogram of oil "A" and 480 grams of oil "B" were used. The results of

TABLE 2

Boiling Points °C.	Boiling Points °F.	% Oil	Specific Gravity	A.P.I. Gravity	Ostwald Discharge time sec. at 20°C.	Specific Viscosity = *Ostwald Discharge* Water Equivalent	Absolute Viscosity = Specific Viscosity × vis. H_2O at 20°C.	Ostwald Discharge Time sec. at 50°C.	Specific Viscosity = *Ostwald Discharge* Water Equivalent	Absolute Viscosity = Specific Viscosity × Vis. H_2O at 50°C.	Aniline Point before H_2SO_4 Treatment °C.	Aniline Point after H_2SO_4 Treatment
					OIL "A"							
110–125	230–257	1.1	0.7373	60.4	.....	.....	.....	.....	.....	.....	.....	.....
125–140	257–284	2.2	0.7395	59.8	.....	.....	.....	.....	.....	.....	.....	.....
140–155	284–311	2.6	0.7566	55.5	5.5	1.06	0.01064	.....	.....	.....	.....	.....
155–170	311–338	2.2	0.7570	55.4	5.5	1.06	0.01064	.....	.....	.....	.....	.....
170–185	338–365	1.9	0.7676	52.8	7.0	1.34	0.01345	.....	.....	.....	.....	.....
185–200	365–392	1.9	0.7725	51.7	7.5	1.44	0.01445	.....	.....	.....	.....	.....
200–215	392–419	1.3	0.7842	48.9	9.7	1.87	0.01877	.....	.....	.....	.....	.....
215–230	419–446	1.3	0.7938	46.8	11.7	2.14	0.02149	.....	.....	.....	.....	.....
230–245	446–473	4.2	0.8045	44.4	16.5	3.17	0.03183	.....	.....	.....	71.6	.....
245–260	473–500	4.5	0.8148	42.2	24.0	4.61	0.04628	.....	.....	.....	72.1	.....
260–275	500–527	4.0	0.8233	40.4	35.0	6.73	0.06757	.....	.....	.....	73.0	.....
275–290	527–554	1.3	0.8303	38.9	56.0	10.77	0.10813	.....	.....	.....	76.0	.....
290–305	554–581	2.5	0.8333	38.3	67.5	12.98	0.13032	.....	.....	.....	77.0	.....
Above 305 At 8mm.	Above 581 At 0.32"	4.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
170–185	338–365	3.0	0.8555	33.9	207	39.8	0.39959	.....	.....	.....	84.0	94.5
185–200	365–392	1.8	0.8570	33.6	312	60.77	0.61013	.....	.....	.....	86.5	94.5
200–215	392–419	1.9	0.8579	33.4	465	89.42	0.89778	.....	.....	.....	89.0	109.0
215–230	419–446	4.7	0.8631	32.4	955	183.65	1.84385	.....	.....	.....	93.0	109.0
230–245	446–473	6.0	0.8647	32.1	1524	293.08	2.94252	.....	.....	.....	95.5	112.0
245–260	473–500	7.6	0.8669	31.7	4520	913.4	9.17054	384	73.9	0.40867	101.5	121.0
260–275	500–527	6.3	0.8694	31.3	8803	1693.0	16.99772	616	118.4	0.65572	113.0	124.0
275–290	527–554	3.0	0.8711	30.9	9413	1810.0	18.17240	707	136.0	0.75208	114.0	124.0
Above 305	Above 581	7.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
TOTAL....	.....	75%	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
					Combined Oil "B"							
130–160	266–320	2.1	0.7629	54.0	6	1.14	0.01145	.....	.....	.....	51.8	63.5
160–190	320–374	3.1	0.7832	49.2	6.5	1.25	0.01255	.....	.....	.....	50.8	63.5
190–200	374–392	4.6	0.8046	44.4	9.0	1.54	0.01547	.....	.....	.....	50.5	63.5
200–250	392–482	4.2	0.8274	39.5	18.5	3.56	0.03574	.....	.....	.....	52.8	69.0
250–280	482–536	7.0	0.8429	36.4	43.0	8.27	0.08313	.....	.....	.....	57.2	77.5
280–310	536–590	11.4	Crystals	.....	.....	.....	.....	.....	.....	.....	.....	.....
Above 310 At 8 mm.	Above 590 At 0.32"	4.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Below 180	Below 356	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
180–200	356–392	7.7	0.8670	31.7	568	19.0	0.19076	.....	.....	.....	76.5	96.5
200–240	410–464	8.8	0.8757	30.1	993	416.0	4.17664	229	44	0.24332	85.5	109.0
240–270	464–518	18.3	0.8819	29.0	11,152	21,473.	215.58892	935	181.3	1.00259	108.0	123.5
Above 270	Above 518	4.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

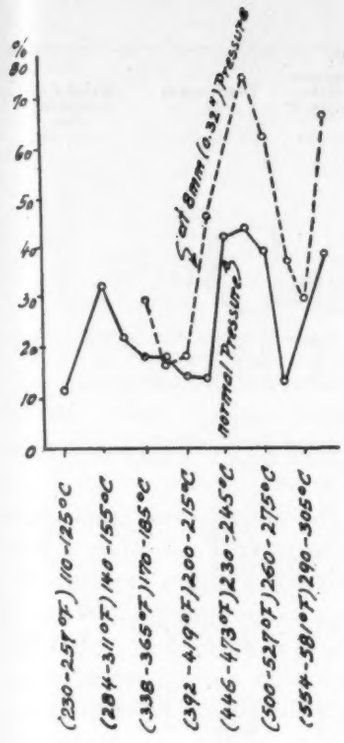
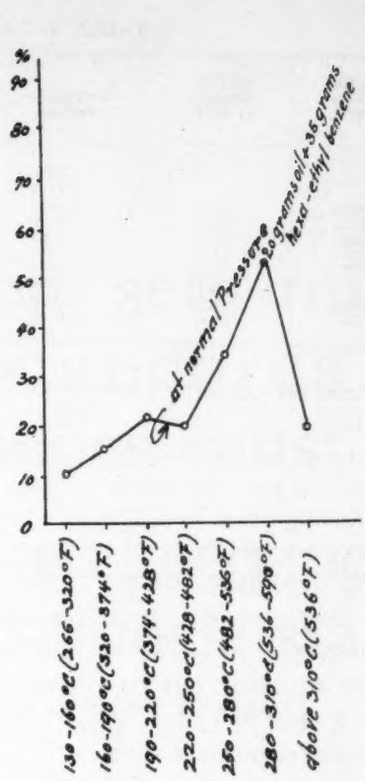


Fig. 1



Distillation at normal pressure.

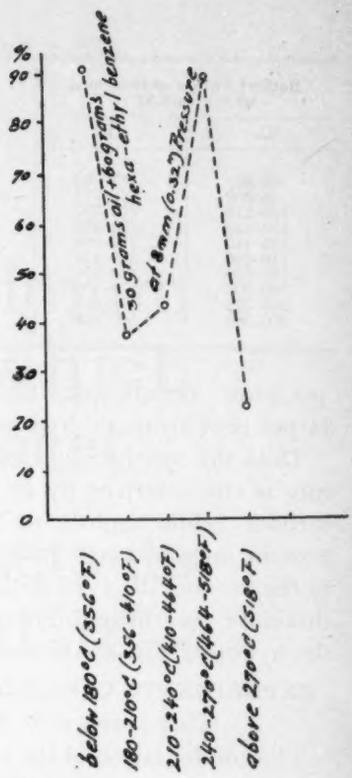


Fig. 2

Vacuum distillation.

the distillation are reproduced in diagrams 1 and 2. These curves are the result of a fourfold distillation.

They permit the conclusion that synthetic oils are composed of a smaller number of individuals than oils from natural crude oil. Thus, it appears possible by fractionating these oils on a commercial scale to obtain lubricating oils with standard qualities. It is worth while noting that a solid substance, namely the hexa-ethyl benzene of 129°C. (265°F.) melting point was found in these oils. The "A" oil contained two per cent and the "B" oil 20 per cent of this compound. According to Nash[8], who also established the formation of hexa-ethyl benzene in his experiments, condensing ethylene alone, this phenomenon is due to the presence of benzene in the solvent —petroleum ether. We used a low boiling petroleum ether (boiling up to 75°C. (167°F.)), which contained only traces of benzene. Only 200 cc. of petroleum ether was applied in both experiments which yielded 2 kilograms of a condensate, whereby about 120 grams of hexa-ethyl benzene were obtained. Thus, it is quite obvious that hexa-ethyl benzene was obtained from ethylene, maybe via benzene. But this is only in case the benzene was farmed from ethylene by the Hague and Wheeler method.[9]

The fractionated oils were investigated in a manner described recently by M. Bestuzhev, who investigated natural lubricating oils from crudes of various origin. This was done for the purpose of comparing synthetic with natural lubricating oils.

The results of the investigation are given separately for oil "A" and oil "B" in Table 2.

The obtained oils in their viscosity can stand the comparison with synthetic oils prepared by Otto in the presence of BF_3 as well as with the American petroleum oils as shown in the table below, reproduced from Otto's paper.[10]

When comparing the data given in the table with those obtained by M. Bestuzhev from various natural petroleum oils it becomes apparent that synthetic oils prepared at room temperature are characterized by a higher content of paraffin hydrocarbons (and a correspondingly lower content of aromatic hydrocarbons) than present even in the Grozny paraffinic crude. This is manifested by the lower specific gravities of the fractions as well as by aniline points before and after sulfuric acid treatment. The latter data were checked by direct determination of aromatic hydrocarbons (removed by sulfuric acid), the content of aromatics varying between 12 and 20 per

TABLE 3

A comparison of the viscosities of synthetic oils with those of American petroleum oils (according to Otto)

Temperature		Absolute Viscosity = Ostwald Viscos'ty divided by 100			
°C.	°F.	Synthetic Oil I	Spindle Oil	Synthetic Oil II	Compressor Oil
20	68.0	0.68	0.53	3.93	3.84
50	122.0	0.147	0.131	0.438	0.438
100	212.0	0.037	0.038	0.090	0.095

[8]Loc. cit.
[9]The high yield of hexa-ethyl benzene may be explained by the admixture of butadiene present in the original "ethylene concentrate."
[10]M. Otto. Brennstoff Chem. :8, 321-3 (1927); Chem. Abstr. :22, 1465 (1928).

TABLE 4

Boiling Points of fractions at 8 mm(0.32") °C.	°F.	Specific Gravity at 20°C.	A.P.I. Gravity at 68°F.	Refractive Index	Aniline pts. before H_2SO_4 Treatment °C.	Aniline pts. after H_2SO_4 Treatment °C.	Depression °C.	Weight of Fractions Grs.
65–85	149–185	.....	.....	1.4670	.....	.....	.....	41
85–100	185–212	.....	.....	1.4714	.....	.....	.....	35
100–110	212–230	0.8164	41.8	1.4812	36.7	.....	.....	45
110–125	230–257	0.8172	41.6	1.4846	46.8	.....	.....	45
125–145	257–293	0.8538	34.3	1.4885	55.8	.....	.....	60
145–160	293–320	0.8571	33.6	1.4903	61.8	.....	.....	60
160–180	320–356	0.8571	33.6	1.4929	62.5	79.8	17.3	80
190–205	374–401	0.8871	28.0	1.4980	74	82.7	8.7	65
205–225	401–437	0.9065	24.6	1.5076	75.3	81.3	6	78
260–280	500–536	0.9233	21.7	1.5080	89	89	0	85

per cent. Grozny paraffinic crude oil contains 22 to 34 per cent aromatic hydrocarbons.

Thus the synthetic oil obtained at room temperature is characterized by an excess of paraffin hydrocarbons, while naphthenic hydrocarbons, if any, are present only in very small quantities. They belong to the monocyclic type with long side chains and are therefore very little different in their properties from the hydrocarbons of the paraffin type.

EXPERIMENTS CARRIED OUT AT 100°C. (212°F.)

(Data supplied by E. A. Pozhilzova.)

The condensation of the ethylene concentrate when carried out at 100°C. (212°F.) proceeds at a much higher velocity than at room temperature (about two or three times as fast). Thus in this case a condensate amounting to ten times of the weight of the catalyst was collected after four to six days heating (8 hours every day). The condensation reaction proceeded at the beginning very slowly and later on at a high velocity. It should be noted that the life of the catalyst is not limited by the condensation of the ten fold amount of oils. The condensation experiments could have been continued with the old catalyst and in that case, when working on a commercial scale, the consumption of the catalyst could probably be lowered considerably below 10 per cent. The experiments at 100°C. (212°F.) were carried out without agitation (because of the lack of the corresponding equipment). On the basis of the experiments carried out at room temperature the yields at 100°C. (212°F.) should have been higher than the actual yield obtained when agitation would have been used. In this case however, we obtained only traces of the "B" oil. In the following distillation and further investigation 650 grams of oil "A" were used. The results of this investigation are given in Table 4.

Only very low yields of fractions boiling at 180-190°C. (356-374°F.) and 225-260°C. (401-500°F.) were obtained and they were not investigated for this reason. The residue boiling above 280°C. (536°F.) could not be distilled without decomposition. It amounted to 30 grams.

As can be seen from the above data, condensate fractions obtained at 100°C. (212°F.) contain a considerable amount of unsaturates and aromatics (removable with H_2SO_4), they amounted to 20 to 40 per cent. This fact was also confirmed by individual experiments applying agitation with three volumes of H_2SO_4. However, hexa-ethyl benzene obtained in such considerable quantities in the experiments at room temperature was obtained only in very small quantities, which were below 0.1 per cent.

Judging by their specific gravity, refractive index, and by the aniline points these synthetic oils are very similar to the natural crude oil fractions investigated by M. Bestuzhev.

The viscosities of synthetic oils are reproduced in Table 5.

When comparing oils, "A" obtained at room temperature with those obtained at 212°F. a much higher amount of aromatics present in the latter is noted. This is true for the total of fractions and quite particularly for the higher boiling fractions. This fact was established by the aniline points as well as in the direct determinations with sulfuric acid. The higher content in aromatics may explain the higher viscosity. It is difficult to draw more definite conclusions on this problem because oils obtained at 212°F. were distilled only once while those prepared at room temperature were distilled four times, this causing a slight lowering of their viscosity. However, oils produced at 212°F. are characterized by a steeper viscosity curve while those produced at room temperature have a flatter viscosity curve (compare viscosity data at 68 and at 122°F. in both cases). To obtain a better knowledge on synthetic oils they should be prepared on a semi-manufacturing scale.

TABLE 5

Boiling Points of Fractions at 8 mm.(0.32") °C.	°F.	Specific Gravity at 50°C.	A.P.I. Gravity at 122°F.	Viscosity at 20°C. (68°F.) Ostwald Viscosity	Viscosity at 20°C. (68°F.) Discharge Period	Viscosity at 50°C. (122°F.) Ostwald Viscosity	Viscosity at 50°C. (122°F.) Discharge Period	Notes
145–160	293–320	0.8320	38.6	23.53	2 min. 3s	6.27	32s	Water equivalent of apparatus 5.2 sec.
160–180	320–356	0.8407	36.8	82 35	7 " "	19.53	1 min. 39"	
190–205	374–401	0.8705	31.0	443.52	37 " 22"	45.49	3 " 52"	
205–225	401–437	0.8944	26.7	1456.86	123 " 50"	109.01	9 " 6"	
260–280	500–536	0.9020	25.4	.....	.....	639.0	54 23"	

Competition sets minimum anti-knock standards which ordinary gasolines must meet

Dubbs cracked gasoline sets its own high anti-knock standard—it is in a class by itself

There is too much ordinary gasoline—there never has been enough Dubbs cracked gasoline

Dubbs cracking makes the biggest yield of the best anti-knock from any charging stock at lowest cost—royalty and all

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SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstract, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Chemical, Composition and Research

Behavior of Trimethylene Sulphide in Heptane and Naphtha Solutions. R. W. Bost and M. W. Conn. *Ind. Eng. Chem.* **25** (1933) pp. 526-28.

The work reported is a continuation of that of the authors on the thiophanes. Trimethylene sulphide reacts readily with mercuric chloride, methyl iodide, potassium permanganate, and 30% hydrogen peroxide to give stable derivatives. Bromine gives a product that decomposes readily at —15°C. Mercuric iodide does not react. Nitric and hydrochloric acids give highly polymerized products. Trimethylene sulphide behaves like the higher members of the thiophane series in that it resembles the alkyl sulphides more than thiophene in its chemical properties. It differs from tetramethylene and pentamethylene sulphides in its reactions with concentrated nitric and hydrochloric acids.

Composition and Knock Rating of Straight-Run Pennsylvania Gasoline. M. R. Fenske. *Pa. State College, Mineral Industries Expt. Sta. Bull.* **11** (1932) pp. 1-8.

The crude oil from the Bradford, Pa., field was topped, distilled to 510°F. and separated into 165 fractions. The specific gravities, boiling points, refractive indicies and knock ratings were determined. Knock rating was found alternately high and low, but was found progressively poorer as the boiling point increased. The alternate high and low values are caused by segregation of normal paraffins in fractions of poor knock rating. The fraction boiling from 175 to 225°F. was refractionated and the hydrocarbons contained in it isolated. The properties of these hydrocarbons are given. It is concluded that the poor knock rating of straight-run Pennsylvania gasoline is caused principally by the presence of normal paraffin hydrocarbons that comprise in total less than 20% of the gasoline.

Thermal Decomposition of Isobutane into Primary Products. L. F. Marek and Max Neuhaus. *Ind. Eng. Chem.* **25** (1933) pp. 516-19.

The thermal decomposition of isobutane at 600°C. and 650°C. was studied to determine the primary reactions. Data were secured covering a fairly wide range of reaction and plotted so that the curves could be extrapolated to zero reaction in order to show the extent of the several reactions. In the order of importance the reaction products were (1) hydrogen and isobutylene, (2) methane and propylene, and (3) ethane. Reaction velocity constants were calculated for 600°C. and 650°C. By the use of over-all dissociation-rate constants and primary reaction distribution the velocity constants for the primary reactions of ethane, propane, n-butane and iso-butane over the range 550°-650°C. were calculated.

Fundamental Physical Data

Total Heats and Specific Heats of Petroleum Waxes. C. M. Gateley. *Fuel* **12** (1933) pp. 26-29.

Four Persian and three Burmese waxes, a white ceresine, and an ozokerite have been studied with determination of total heats from the melting point to 300°C. For engineering purposes the specific heat of any of the waxes is given with sufficient accuracy by the equation $s = 0.492 + 0.0009t$, and the total heat by $H = 0.492t + 0.00045t^2 - 20.40$.

Importance of Refraction Values of Benzines. P. Lob. *Angew. Chem.* **46** (1933) pp. 91-92.

Determination of the refractive index is a valuable guide to the nature of the components of hydrocarbon mixtures. Different mixtures may have substantially the same specific gravity and boiling range, but it will be found that there may be appreciable difference in refractive indicies.

Solubility of Ethyl Alcohol in Gasoline. O. C. Bridgeman and D. Querfeld. *Ind. Eng. Chem.* **25** (1933) pp. 523-25.

One of the principal difficulties in the use of alcohol-gasoline blends is the limited solubility of ethyl alcohol in gasoline. This is particularly serious in those climates that have freezing temperatures. The literature on the solubility of alcohol in gasoline is reviewed. The laboratory study included the preparation of solutions of alcohol (containing known proportions of water) in gasoline and measuring the critical solution temperature by noting the appearance of a second phase on cooling. Twenty-three typical gasolines were used and eight alcohol solutions containing 1.13% to 8.27% of water by volume. The temperature range covered was +65°C. to —65°C. The data are presented in tabular and in graphical form.

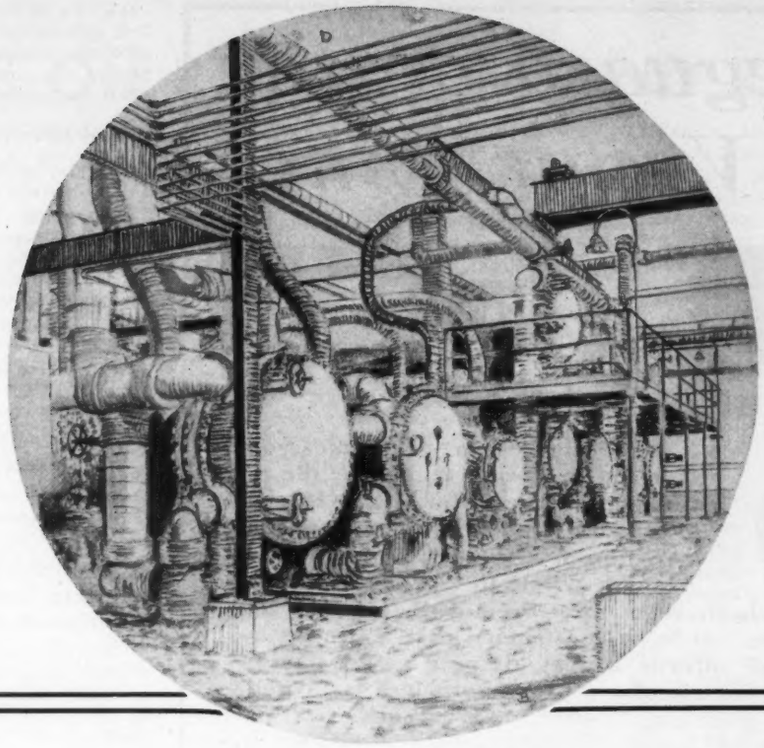
Manufacture: Processes and Plant

Sulphur Content of Crude Naphtha from Turner Valley in Relation to Refining Practice. J. W. Shipley. *Can J. Research* **8** (1932) pp. 119-28.

The sulphur content of Turner Valley naphtha was found to be 0.15 to 0.19% and to comprise sulphides, disulphides, and mercaptans. Thiophenes were present but no free sulphur or peroxides. By distillation the color and color forming compounds and the gum and gum forming compounds were concentrated in a small, high boiling residue. Exposure to light and the presence of air caused the development of yellow color and gum in all undistilled samples, whether treated or untreated. Distillation to a temperature of 165°C. yielded a fraction 95% by volume) that remained colorless and gum free when exposed to air and light for over eight months. Treatment of the crude naphthas with caustic soda solution or with caustic soda solution and sodium sulphide solutions is suggested as a means of producing fairly satisfactory gasoline. Caustic has reduced the sulphur content to about 0.1%. The caustic and sodium sulphide wash reduced it to 0.05%. Treatments of the naphtha with sulphuric acid, hypochlorite, sodium plumbite, and cupric chloride were made but none of these prevented gum formation nor color development when the treated samples were exposed to light.

The Improvement of the Odor of Unsaturated Light Oils. H. von Winkler. *Chem. Z.* (1932) pp. 991.

The investigation was concerned particularly with the improvement of the odor of gasoline made from Estonian shale. Ordinarily, treatment with sulfuric acid, caustic soda and plumbite, followed by distillation, did not remove the yellowish color and unpleasant odor of this gasoline. However, if the usual method of treating was supplemented by the addition of methanol to the sulfuric acid, the malodorous substances in the gasoline become water soluble and are easily washed out. Also, the gasoline becomes water-white and bright in appearance. Other similar treatments are possible. For ex-



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ample, the addition of 0.4% fomalin and some 70% sulfuric acid, will remove the odor from a previously treated gasoline. The shale gasolines handled are unsaturated and contain many sulfur compounds.

Hydrofluoric Acid, a New Refining Agent. H. LEDERER. *Erdol u. Teer* 9 (1933) pp. 107-8.

Hydrofluoric acid has recently been proposed as a refining agent for petroleum oils. Physical properties are given. This acid converts unsaturated hydrocarbons into insoluble polymers. The reagent is readily and completely removed from the oil on account of its boiling point (19.4°C.). Also it does not destroy hydrocarbons. The disadvantage is the high price as compared to sulfuric acid. Also it cannot be used in open tanks on account of its high vapor pressure and poisonous nature. Burns from the acid can be treated with a paste of glycerine and magnesia. The refining action of hydrofluoric acid is catalysed by metal chlorides such as zinc chloride and ferrous chloride.

The Behavior of Sulfur Compounds in Cable Insulation Oils. P. NOWAK. *Petroleum Z.* **29** (1933) No. 2 pp. 1-7.

Cable oils may contain 1-10% of sulfur compounds, consisting in part of mercaptans of high molecular weight. 30% of these compounds can be removed by means of adsorbents, but by so doing a 3 to 5 fold reduction in electric resistance, as well as an increase in the tendency toward oxidation, is occasioned. However, treatment with mercuric oxide, or Hg-Cu results in a larger decrease in sulfur content, but an increase in electric resistance of 10 to 20 times, respectively. Addition of mercaptans and dialkyldisulfides does not affect resistance or formation of wax, but does decrease the rate of oxidation. Like other sulfur compounds these substances cause a sharp reduction in the dielectric constant. Laboratory methods for the determination of sulfur are discussed and the method of Rothe, involving oxidation with magnesium oxide and nitric acid, is recommended.

Products: Properties, Utilization and Testing

Predicting Stability of Gasolines to Aging. C. WINNING and R. M. THOMAS. *Ind. Eng. Chem.* **25** (1933) pp. 511-16.

As gasoline ages some of the components are oxidized and some of the oxidation products are not completely vaporized when the gasoline is used in the engine. Deposits are thus formed on the walls of the intake manifold and valves. Some gasolines deteriorate more rapidly than others and methods for measuring gasoline stability have long been sought. The methods used are briefly reviewed. The paper is a report on studies extending over a several year period in which an effort was made to correlate laboratory methods with storage. The authors conclude that the break-down at 100°C. can be determined with fair speed and accuracy by following the pressure-time curve obtained upon heating the gasoline under oxygen pressure in the apparatus described. The point at which a two-pound/square inch drop is recorded can be taken as indicating the break-down when dealing with similar gasolines. Break-down determinations at temperatures lower than 100°C. are regarded as difficult to obtain and of questionable utility. It is concluded that no single accelerated test now available will adequately predict the resistance of a gasoline to aging. However, by using the copper dish method in conjunction with the break-down test, fairly accurate predictions can be made. Studies are

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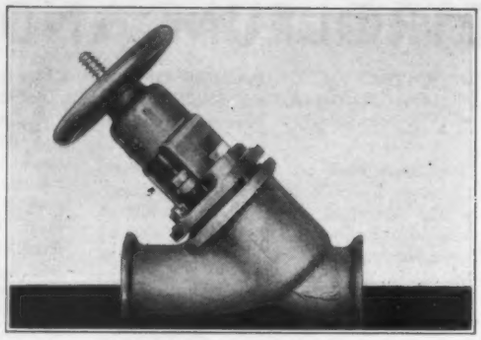

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being conducted to incorporate the desirable features of the copper dish method with the break-down test.

Gum Formation in Gasoline. II. Control of Gum Formation in Gasolines by Antioxidants. T. H. ROGERS and V. VOORHIES. *Ind. Eng. Chem.* **25** (1933) pp. 520-23.

Use of antioxidants is regarded as a particularly suitable method for preventing the formation of gum in cracked gasoline. The effectiveness of a large number of antioxidant compounds has been tested by the Voorhies method. It was found that the increase in the induction period is directly proportional to the concentration of antioxidant. Readily oxidizable compounds have been regarded as the most effective inhibitors. Thus mono-substituted p-aminophenols are shown to be particularly effective. p-benzylaminophenol has marked advantages over compounds previously proposed as inhibitors, as a-naphthol and the polyphenols, since it is more than twice as soluble in gasoline as in water and is color stable. Also, it generally increases the color stability of the gasoline.

The Use of Synthetic Methanol as a Motor Fuel. D. A. HOWES. *Jour. Inst. Petrol. Tech.* **19** (1933) pp. 301-32.

Methanol has the disadvantage of a low calorific value and at the same time compression ratio, the relative fuel consumptions of methanol, ethyl alcohol, and No. 1 petrol are 221.6, 161.4 and 100, respectively. However, contrary to general belief, methanol has a high anti-knock value and does not preignite. In engines without supercharger it can be used at compression ratios up to 15.1. On account of the high latent heat of vaporization methanol can be used at high volumetric efficiency and the power output of the engine is higher than with any other fuel. Methanol has been used extensively as a racing fuel. When mixed with petrol it has an anti-knock value 1.8-2.0 times that of benzol. Unfortunately, methanol is not miscible in all proportions with all petrols. A table of solubilities is given. The solubility depends on the temperature, the presence of water, and the nature of the hydrocarbons. Methanol is least soluble in the paraffins and most soluble in aromatics. In any hydrocarbon series, the higher the b.p. the lower the solubility of methanol. Solubility diagrams are presented for several ternary systems. The effect of the presence of water is discussed.

Czechoslovakian Alcohol - Gasoline Mixture. ADOLF BALADA. *Chem. Obzor.* 7 (1932) pp. 240-4.

When gasoline and alcohol are mixed, there is an increase in volume and a drop in temperature. The characteristic properties of gasolines change markedly on addition of alcohol. This is of importance in judging starting properties if the 10% point is used and is a criterion. Values of octane numbers of Czechoslovakian gasolines and alcohol-gasoline mixtures are given.

Influence of Humidity on Knock Determinations. A. W. SCHMIDT and F. SEEBER. *Erdol u. Teer* **8** (1932) pp. 493-5.

Tests were made under standard conditions and with accurate control of relative humidity. Humidity has little effect upon the octane number if the relative humidity is below 40-45%, but above 50% the knock rating increases. This increase is more rapid for fuels of low octane number than for those of high knock rating. A

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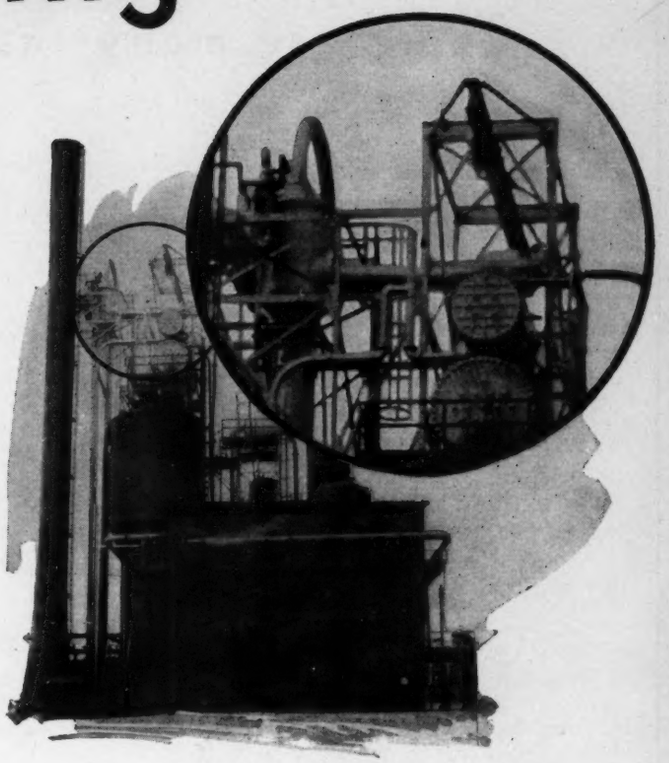

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space model was worked out relating the relative humidity, octane rating, and benzine content. By the use of this, it is possible to eliminate the effect of humidity for knock determinations.

Carbon Deposits in Gasoline Engines. W. A. GRUSE. *Am. Soc. Testing Materials, Symposium on Motor Lubricants (preprint)* (March 8, 1933) pp. 20-34.

Available information on the formation of carbon deposits in gasoline engines is reviewed. Particular attention is given to the influence of lubricating oils on the formation of carbon deposits. The tests devised to indicate the carbon depositing tendency of oils is discussed. Factors involved are engine temperature, speed and load, oil consumption, intervals of cleaning, air-fuel ratio, dust content of air, engine design, characteristics of the oil and characteristics of the gasoline. Carbon deposits were found to be complex mixtures containing little free carbon, but large proportions of asphaltic matter and inorganic material.

An Investigation of Petroleum Oils for Malarial Control Purposes. G. C. RAMSAY and J. A. CARPENTER. *Rec. Malaria Surv., India.* **3** (1932) pp. 203-18.

It is noted that the larvicidal properties of petroleum oils vary greatly. The products available from India were examined in order to find an efficient larvicide. The ideal larvicide would have a high toxicity to larvae, but at the same time would be harmless to higher life forms, would have good spreading power on water and good lasting power. The authors conclude that the viscosity of the larvicide should be between 3 and 15 c.p. at 25°C. and preferably nearer the lower limit. The killing effect of the larvicide depends not only on asphyxiation, but on toxic poisoning. Hence, the oil must not only have the proper viscosity and surface tension so that it will enter the breathing tubes and mouths of the larvae, but it must also be toxic. Light oils kill most rapidly. When the average boiling point of the fraction rises above 200°C. the toxic effect decreases. However, when special cuts of aromatics and unsaturates are prepared, it is possible to make blends having a killing power equal to, or better, than that of the light cuts. Experimental results are presented in tabular form.

Service Changes in Crankcase Lubricating Oils. M. A. DIETRICH. *Am. Soc. Testing Materials, Symposium on Motor Lubricants* (preprint March 8, 1933) pp. 35-54.

Dilution of crankcase oil in service causes a decrease in viscosity, flash and fire point, and pour point, but an increase in carbon residue and in the ease of emulsification with water. These changes are more dependent upon the type of engine and its condition and manner of operation, than on the characteristics of new oil as determined by laboratory tests. The extent of the change of characteristics of a motor oil in service can be modified by the use of air cleaners and oil filters or purifiers. The use of these devices permits cars to run many thousand miles on the same oil.

Viscosity of Automobile Crankcase Oils as Related to Service Requirements. E. W. UPHAM. *Am. Soc. Testing Materials, symposium on Motor Lubricants* (preprint March 8, 1933) pp. 14-19.

The viscosity must be such as to insure starting of the engine in cold weather, prevent ex-

cessive oil consumption and insure fluid-film lubrication. Results indicate that an oil with a maximum viscosity of 50,000 seconds at 0°F. is desirable for the average engine. Below 0°F. the limiting viscosity is less. The viscosity of the oil of the walls of the engine cylinders affects the revolutions of the starter more than that of the oil on the engine bearings. Other minor considerations, such as gasoline consumption and cushioning of bearings, are discussed. In general, it is necessary to use one range of viscosity for cold weather and another range of viscosity for warm weather, the first based on starting requirements and the second based on consumption.

Present Concepts of the Relation of the A. S. T. M. Pour Test to Service Requirements of Oils. J. L. McCLOUD. *Am. Soc. Testing Materials, Symposium on Motor Lubricants* (preprint March 8, 1933) pp. 3-13.

Several modifications have been proposed for the pour point test as a criterion of the performance of lubricating oils at low temperatures. The pour point test is one of suitability, rather than of quality. The relation between pour point and starting of the engine and pumpability, is well defined. Coastal oils pump better than Mid-Continent or Pennsylvania dewaxed oils of the same viscosity. Use of high pour test oils drains the battery used in starting to a much greater extent than the use of low pour point oils.

The Aging Tendency of New and Used Transformer Oils with Respect to the Formation of Sludge. K. O. MULLER, F. G. CONSOLATI, F. FRANK, and G. MEYERHEIM. *Erdol und Teer* **8** (1932) pp. 525-27, 540-42, 557-58.

The apparatus used is described and instructions are given for making determinations. The time in hours required to produce the first trace of precipitate insoluble in the oil at 115°C. is measured. Quantity of precipitate and acid content of the oil was also determined when longer periods of heating at 115°C. were used. Precipitate curves were plotted that vary with the nature and age of the oils. Three classes of oils are to be distinguished: (1) new oil with a period of 0 hours and a parabolic curve; (2) oils that sludge quickly and have a parabolic curve; (3) aged oils with a linear curve and sludge already separated in the transformer. The authors discuss the value of the sludge curve, the probability of change of the oils in use, the significance of double curves over refined oils, and the relationship between the period of the oil and the course of its precipitation curve. The probable behavior in transformers of oils with a tendency to age, and also the question of the time that an oil should be used before changing, are discussed.

Emulsified Asphalt Industry Ignores the Depression. J. M. FAIN and A. W. HIXSON. *Chem. & Met. Eng.* **40** (1932) pp. 180-1.

Sales of emulsified asphalt gained 37% in 1931 as compared to 1930. Advantages over fused asphalt are elimination of heating kettles, possibility of application in damp weather, reduction in quantity of asphalt required, voids are filled with aggregate and asphalt is used only as a coating, prevention of bleeding or displacement under traffic, and road construction is not limited to seasons of mild weather. The uses of asphalt emulsions in road construction, for coating wood or metal, as a binder in mastic flooring, as a cement for rubber and composition tile, and as a sound deadening material for automobile bodies are briefly described.

Significance of A. S. T. M. Distillation Curve. M. G. BLAIR and R. C. ALDEN. *Ind. Eng. Chem.* **25** (1933) pp. 559-62.

The authors review previous contributions relating to the correlation of the A.S.T.M. distillation curve of motor fuels and performance in the automobile engine. Summary charts are presented related to the estimation of composition, gravity, and vapor pressure. Curves are also presented and discussed by means of which the A.S.T.M. distillation curves of motor fuels can be used to estimate the composition, vapor pressure, and minimum temperature at which incipient vapor lock can be expected.

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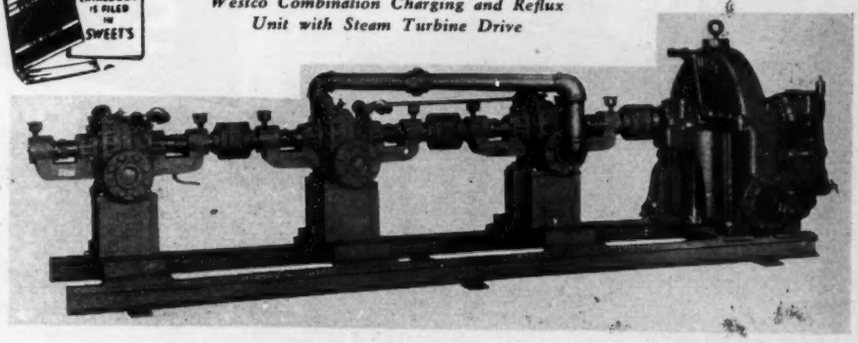

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THE MONTH IN REVIEW

California Natural Gasoline Association Elects Officers

AT the annual meeting of the California Natural Gasoline Association's board of directors at the Los Angeles Athletic Club, the following officers were installed: N. H. Mull, president. Mr. Mull is general superintendent of natural gas and gasoline operations on the Pacific Coast for The Texas Company. H. L. Eggleston, vice president. Mr. Eggleston is manager of the gas and refining department of Gilmore Oil Company, and for the fourth year, Wallace McIlhany, secretary-treasurer.

Directors for the association include A. H. Bell, Continental Oil Company; T. L. Taggart, Standard Gasoline Company; A. H. Bradford, West Coast Refining Company; R. C. Wheeler, General Petroleum Corporation; R. D. Gibbs, Union Oil Company; R. W. Heath, Signal Oil & Gas Company; J. N. Hicks, Superior Oil Company; H. R. Linhoff, Richfield Oil Company; S. F. Magor, Kettleman North Dome Association; H. E. Moulton, C. C. M. O. Company; W. D. Smith, Wilshire Oil Company; E. L. Tobias, Norwalk-Bankline Company; R. S. Tulin, Shell Oil Company; J. S. Watson, Shell Oil Company; Oliver Weaver, Barnsdall Oil Company; W. M. Young, The Texas Company; L. V. Cassaday, Lomita Gasoline Company; Earle Derby, Standard Gasoline Company; O. C. Field, Field Gasoline Corporation; R. H. Green, Signal Oil & Gas Company; A. S. Hayes, Kettleman North Dome Association; R. E. Haylett, Union Oil Company; Frank Coyle, Associated Oil Company; R. S. Lytle, Los Nietos Petroleum & Refining Company; P. S. Magruder, General Petroleum Corporation; E. R. Pratt, Honolulu Consolidated Oil Company; W. N. Roper, Western States Gasoline Company; M. P. Simon, State Gasoline Corporation; R. E. Wells, Jr., Rio Grande Oil Company.

Lawson, President Elect of A.S.T.M.

PROFESSOR T. R. Lawson, head of the Departmen of Civil Engineering, Renselaer Polytechnic Institute, Troy, New York, has been elected president of the American Society for Testing Materials for the 1933-1934 term. He succeeds Cloyd M. Chapman, consulting engineer, New York. The new president has been active in A.S.T.M. work for the past 25 years.

Herman von Schrenk, consulting timber engineer, St. Louis, has been elected to the two-year term of vice president of the society. Members of the executive committee recently elected include Frank A. Barbour, consulting hydraulic and sanitary engineer, Boston; Arno C. Fieldner, chief engineer, Experiment Stations Division, U. S. Bureau of Mines, Washington; C. N. Forrest, representative, Barber Asphalt Company, Philadelphia; J. C. Pearson, director of research, Lehigh Portland Cement Company, Allentown, Pennsylvania, and A. E. White, professor of Metallurgical Engineers and director Department of Engineering Research, University of Michigan, Ann Arbor, Michigan.

A.S.T.M. Chart for Non-Plastic Asphalts

INVESTIGATIONS on the viscosity and plasticity of plastic and non-plastic asphalt bitumens recently reported by Dr. R. N. J. Saal and G. Koens in an interesting paper (Journal, Inst. Pet. Tech., Vol. 19, p. 176 (1933), show that the A.S.T.M. Viscosity-Temperature Chart (D 341-32 T) may be used for the viscous or non-plastic type asphalts as well as for lubricating oils. Their experiments show that it is possible to extend the useful range of the chart to 100,000,000,000 centistokes, which is equivalent to approximately 450,000,000,000 Saybolt seconds.

Dr. J. C. Geniesse (Atlantic Refining Company), who reviewed the paper, reports that the two viscous asphalts chosen for the experiments had the following properties:

	A	B
Specific Gravity at 25 C	1.01	1.02
Melting Point, B. & R., in deg. cent.	33	50
Penetration 100 g. for 5 seconds at 0 C.	5	--
Penetration 100 g. for 5 seconds at 15 C.	71	4.5
Penetration 100 g. for 5 seconds at 25 C.	250+	28.5
Penetration 100 g. for 5 seconds at 40 C.	—	250+
Ductility at 0 C.	0	0
Ductility at 15 C.	100+	100+
Solubility in Petroleum Spirit at 80 C. per cent	99	99

Data were obtained in both a capillary and a Couette viscometer, at temperatures ranging from 5 C. to 125 C. The data fall on a straight line when plotted on the A.S.T.M. Viscosity-Temperature Chart extended by means of the mathematical equation used for its development. This is good news to those who use the chart since there was some question at the time of its development by Committee D-2 on Petroleum Products and Lubricants, concerning its usefulness for asphaltic products.

As a precautionary measure it must be remembered that the chart should not be used on plastic materials such as lubricating oils at temperatures below the cloud point or for blown asphalts, whose viscosity, at any given temperature, varies with the applied shearing stress. No two dimensional charts can be used for plastic materials.

Motor Fuel Forecast Is Being Prepared

QUESTIONNAIRE forms have been sent to the 13 members of the statistical sub-committee of the American Petroleum Institute Committee on Refinery Statistics and Economics to begin compilation of the third quarterly forecast of motor fuel demand for 1933. Members of the committee have been advised by Chairman W. A. Sinsheimer that the report covering the last six months of the year will be prepared for issuance around July 20. In its departure from former practices the statistical committee this year is conducting continuous studies of the factors influencing demand for motor fuel. In its first report issued on March 1, the committee's forecast considered the first six months of this year. The second forecast report, presented at the mid-year meeting of the Institute at Tulsa on May 18, covered the six months from April through September, and it was estimated that the total domestic motor fuel demand for that period would be about 3.4 per cent below the demand for the same period of 1932. The industry was advised that motor fuel stocks on hand September 30 should be about 7,500,000 barrels less than the total on hand at the same date last year, which would reduce stocks below 45,000,000 barrels. It was suggested that crude runs to stills should average approximately 2,237,000 barrels a day and represent only a slight change from the same period a year ago.

In the decision to formulate more frequent forecasts, the committee has taken into consideration unsettled conditions generally in business and industry. Since the committee's last forecast the federal gasoline tax has been increased from one cent to a cent and a half a gallon, and the federal congress has enacted measures designed to improve conditions in industry

of all kinds. Members of the committee who will collaborate in the compil[illegible]n of the forecast are:

W. A. Sinsheimer (chairman), H. L. Doherty & Company, New York; Fred Van Covern (secretary), American Petroleum Institute, New York; W. S. Ackerman, Associated Oil Company, San Francisco; W. C. Allen, The Texas Company, New York; O. S. Ambrose, Tide Water Oil Company, New York; W. B. Case, Shell Petroleum Corporation, St. Louis; E. H. Griswold, Continental Oil Company, New York; L. E. Harman, Standard Oil Company (Indiana), Chicago; C. B. Mapes, Mid-Continent Oil & Gas Association, Tulsa; A. J. McIntosh, Socony-Vacuum Corporation, New York; E. P. Salisbury, Standard Oil Company (New Jersey), New York; J. M. Sands, Phillips Petroleum Company, Bartlesville, and S. A. Swensrud, Standard Oil Company (Ohio), Cleveland.

Pennsylvania Reserves Ample for 20 Years

KNOWN reserves of Pennsylvania grade crude oil, produced under present methods of recovery, are sufficient to lubricate 57 per cent of the automobiles in the United States for over 20 years; while improved production methods and discovery of additional reserves may be expected to increase the above indicated supply.

This estimate was offered here June 29 at the annual meeting of the Pennsylvania Grade Crude Oil Association by one of the various speakers on the program, K. B. Nowles, of Bradford, chief petroleum engineer of the Forest Oil Corporation.

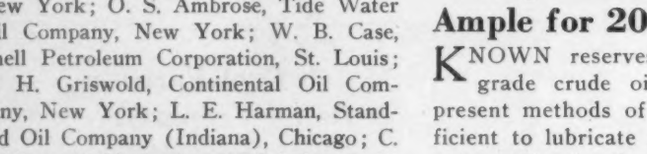
The district in which the Pennsylvania grade oil is produced constitutes one of the nation's important oil reserves, Mr. Nowles asserted, and although the history of this branch of the industry dates back to 1859 it is still virile and will continue so for many years.

In his paper Mr. Nowles estimated the total reserve in the Pennsylvania district at 1,020,000,000 barrels, with each barrel capable of yielding eight gallons of superior lubricating oil. The 21,000,000 passenger cars in operation in the country at the beginning of 1933, using an average of 72 quarts a year, would require 21½ years to consume the 8,160,000,000 gallons of potential Pennsylvania grade motor oil, he estimated.

Mr. Nowles' paper was entitled "Production Methods and Oil Reserves in the Pennsylvania District," and in that part of it dealing with production methods he reviewed the history of the producing industry since the Drake well discovery in 1859 and explained the methods of recovery which have been employed. In this connection he discussed controlled water flooding, such as that now practiced extensively in the Bradford-Allegany area, the reintroduction of gas, repressuring with gas or air, and the de-watering of sands accidentally or unsystematically flooded. Although better crude oil prices must come before wells in some districts can profitably be rejuvenated, new and better methods of recovery which are being worked out may effect increased production much earlier than is now practicable, it was asserted.

P. M. Robinson, research and development engineer of the Pennzoil Company, another speaker on the program, asserted that of all the crudes yet discovered those of the Pennsylvania district most nearly provide the characteristics necessary to fit the lubrication needs of the automobile. His paper was entitled, "The Manufacture of Bright Stock—Present and Future."

Dr. M. R. Fenske, director of the petroleum refining laboratory at State College, presented a series of exhibits June 30, second day of the meeting, to show the importance of homogeneity

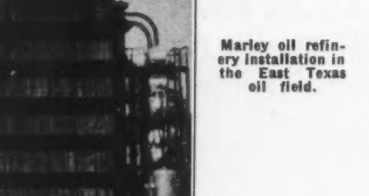


Marley oil refinery installation in the East Texas oil field.

THREE

Outstanding Advantages

1. Marley Patented Spray Nozzles.
2. The Marley Patented Louvred Louvre.
3. Controlled Air Distribution.



Oil refinery installation showing Marley louvred louvre construction.

These three improvements explain why so many oil refineries choose Marley spray deck cooling towers. Their simplicity of construction, more efficient spray distribution and controlled air circulation mean higher cooling efficiency and more economical operation. Write for catalog giving full details.

THE MARLEY COMPANY
1915 Walnut Kansas City, Mo.

MARLEY
SPRAY DECK TOWERS

Another Marley spray deck tower built for an oil refinery.

or uniformity of constituent properties as one of the distinguishing and desirable characteristics of Pennsylvania grade oil when subjected to advanced refining processes.

Also on the second day's program was a talk by Professor H. A. Everett, head of the mechanical engineering department of the Pennsylvania State College, describing original methods used to check the behavior of various lubricating oils, including some specially processed Pennsylvania grade oils developed in the Petroleum Refining Laboratory.

Book on "Chemical Refining of Petroleum"

"CHEMICAL Refining of Petroleum" by V. A. Kalichevsky and B. A. Stagner, published last month as American Chemical Society Monograph Number 63, is an important contribution to the literature on modern refining practice and will prove of real and lasting value to those interested or engaged in chemical treating of petroleum fractions.

The work is an excellent correlation of data appearing in petroleum literature and, further, is based on years of actual experience on chemical treatment. V. A. Kalichevsky is with Socony-Vacuum Corporation in the Research and Development Laboratories. B. A. Stagner, now consulting, was formerly supervisor of chemical research for Union Oil Company of California. Their work covers virtually all of the known and commercially used treating processes, including those developed as late as the early months of this year. It fills a definite need as no previous publication has been given over to the chemical side of petroleum refining.

So much important information is included in this book that it becomes difficult to properly review the work. The following chapter heads are an indication of the comprehensive manner in which the authors have covered this important field: Treatment with Sulphuric Acid; Sulphuric Acid Sludge From Petroleum Refining; Treatment with Alkaline Reagents; Sweetening Operations and the Elimination of Elementary Sulphur; Refining by Absorption; The Use of Solvents in Refining; The Reduction of Total Sulphur in Light Petroleum Distillates; Detonation and Antidetonants; Oxidation and Reduction Reactions; Inhibitors of Atmospheric Oxidation; Gums in Cracked Petroleum Products; Deterioration of Lubricating and Similar Oils; Miscellaneous Refining Processes and Reagents.

In addition there is included a comprehensive supplementary list of Patents on Petroleum Refining as Appendix I. Appendix II is an important group of special tables and charts, and Appendix III is a Glossary of Terms. Finally there is presented a patent index, an author index and a subject index.

The book sells for $7.00 and can be secured through the book department of the Gulf Publishing Company, Box 2811, Houston.

▼ PLANT ACTIVITIES ▼

Rebuilding: The Owens-Libby-Owens Glass Company, Charleston, West Virginia, rebuilding 25,000,000 cubic foot natural gasoline plant, contract to Burrell-Mase Engineering Company.

Modernize: The Sloan & Zook Refining Company will erect a 1500-barrel vacuum distillation unit at Bradford, Pennsylvania, plant. (Refiner, May, 1933, page 43a).

Carbon Black: Imperial Chemical Industries, Ltd., London, England, completed plans for installation of a carbon black plant in the Prahova valley oil field of Roumania.

Refinery: Dixie Oil & Refining Company, capitalized at $50,000, will build a skimming plant at Jackson, under a Mississippi charter, to refine East Texas crude delivered by tank car. Incorporators are E. H. Condon, Charles Wright, and E. T. Moor.

Operating: Associated Oil Company at Avon and Watson, California, has completed erection and is operating new cracking equipment installed at a cost of $1,000,000.

Refinery: Ortiz Oil Company, completing erection of a 2500-barrel refinery at Friar Switch, East Texas field. J. I. Staley and J. C. Wynne, Wichita Falls, president and vice president, respectively. C. A. Middleton, Corsicana, to be general manager.

Gasoline Plant: Standard Gasoline Company (Standard Oil Company of California), completed a small gasoline absorption plant, Mountain View field, capacity 2,000,000 cubic feet daily.

Rebuild: Richfield Oil Company of California, which suffered a loss of $500,000 early in June when its Long Beach plant was destroyed by an explosion, is reported planning reinstallation of the plant.

Purchase: Nate Goodwin and Harry C. Witz of Process Development Company have purchased the Long Beach refinery of Southwest Refinery and Sales Company, capacity 2500 barrels, Southwestern type. Ed. Pann, superintendent.

Modernize: Canfield Oil Company will immediately erect a new tube still and fractionating equipment installation at its Coraopolis refinery, cost $100,000.

Revamping: Western Oil & Refining Company, Wilmington, California, plant, contract to Southwestern Engineering Corporation for revamping Jenkins cracking units.

Improvement: Mohawk Oil Company, Fruitvale, California, has improved operations through installation of a large Southwestern condenser unit.

Improvement: Rio Grande Oil Company, Vinvale, plant, completed installation of a new Southwestern fractionating column.

Modernize: Wolverine Empire Refining Company, Reno, Pa., plant, to install 1800-barrel crude oil distillation unit and a redistillation unit for rerunning pressed distillate, contract to Alco Products, Inc.

Recovery Plant: East Texas Refining Company, Longview, erecting vapor recovery unit to handle gases from skimming and cracking and skimming operation, contract to Ampco, Inc., Dallas, Texas.

Cracking Unit: H. H. Cross Company, Smackover, Arkansas, building refinery cracking unit, contract to Ampco, Inc., Dallas, Texas.

Stabilization: Simms Oil Company, Smackover, Arkansas, refinery installing combination debutanizer-stabilizer-vacuum rerun unit, company design. Foster Wheeler barometric condenser with two steam jets for vacuum.

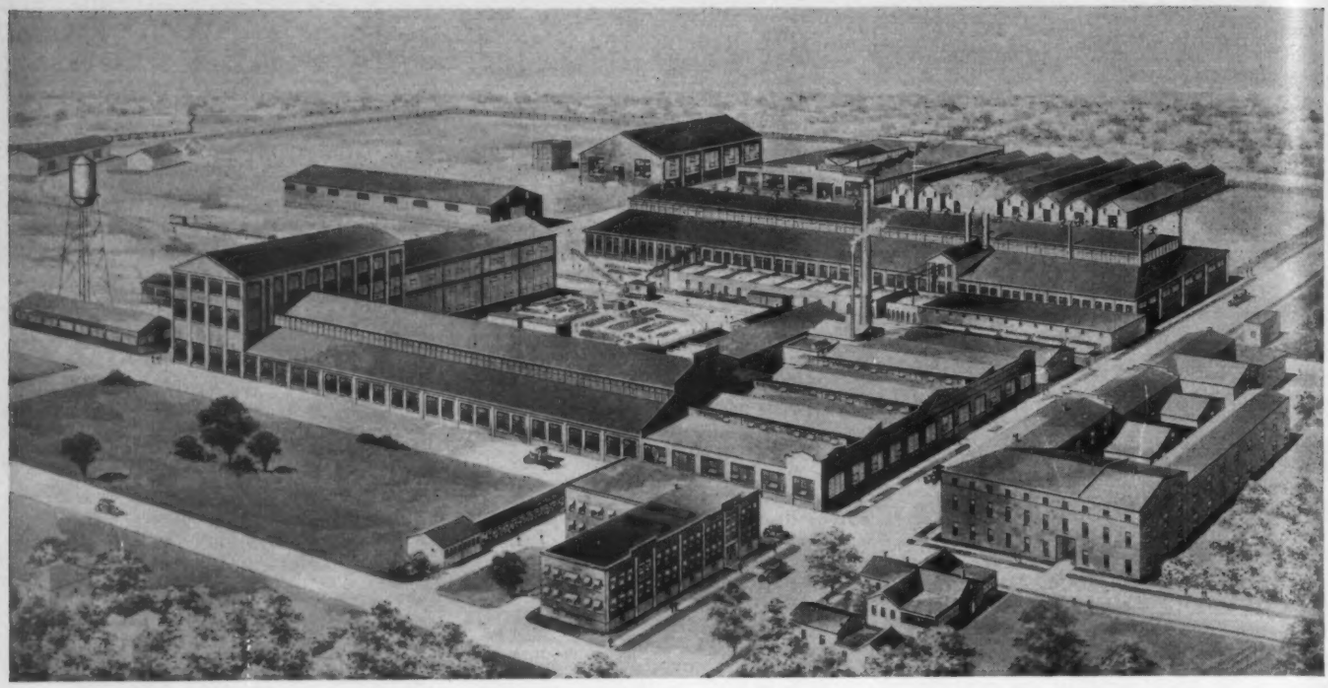
Purchase: Harold Ford, Oklahoma City, reported planning rehabilitation of Brownwood, Texas, plant recently purchased from Cranfill & Reynolds.

Reconditioning: Italo Petroleum Corporation of America reconditioning Long Beach, Cal., asphalt plant to run 100 tons per day. W. D. Rial, superintendent.

Improvement: Gulf Refining Company at its Neville Island plant near Pittsburgh is installing new topping unit and new pulverizing plant. Company is reported planning major modernization program at Port Arthur, Texas, refinery.

CORRECTION

Attention has been called to an error in the short article "Treating Refinery Waste Water to Prevent Contamination" at the Garber Refinery, Inc., Garber, Oklahoma, appearing on page 245 of The Refiner for June, 1933. The plant was not designed and built by International Filter Company, Chicago, as was stated, but was installed by A. Romayne Moberg, chemical engineer, Oklahoma City. The reference to International Filter Company's installation is confusing as this work was done at Champlin Refining Company, Enid, Oklahoma, and was described in The Refiner by A. C. Embshoff, chemical engineer for International Filter Company, in the issue of October, 1932, page 523, under the title "Refinery Waste Water Recovery."



The Cooper-Bessemer Plant at Mt. Vernon, Ohio

Cooper-Bessemer *Had Modest Start* One Hundred Years Ago

ONE day 100 years ago Charles Cooper sat watching the smoke curling up from the old Davis foundry, Zanesville, Ohio, and decided upon the foundry business as his. The inspiration resulted in a visit to the Davis foundry, for information; later interesting his brother Elias Cooper; then the sale of one of the Cooper horses for $50.00—with which the bottom and staves for the first cupola for melting iron was purchased. This was the beginning, in 1833, at Mount Vernon, Ohio.

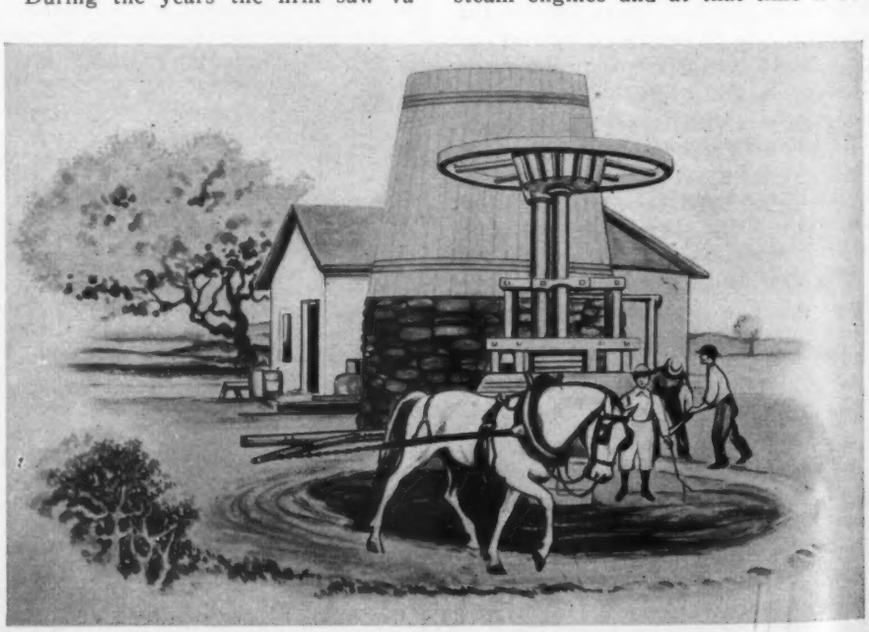
At the spot where the Cooper Brothers developed their iron foundry business, making plowshares and sap kettles for a farming community, is now a manufacturing concern producing modern gas engines, compressors and Diesel engines for the world. The Cooper foundry of 1833 sired The Cooper-Bessemer Corporation of 1933.

The C. & G. Cooper Company first engaged in the production of castings for plows, carding machines and saw mill machinery. A few years after the cupola fan with its horsepower rig was constructed, the panic of 1837 threatened to wipe out the infant industrial plant, but the brothers hung on and a little more than a decade later built the first steam locomotive manufactured west of the Alleghenies. This was delivered to the Baltimore & Ohio Railroad and was followed by others of the same type.

In the late 50's the Coopers designed and built the Corliss engine for distribution in the west and shared for several decades in the popular reception of that famous old steam plant.

During the years the firm saw various changes in name and personnel but in 1895 the business was incorporated as The C. & G. Cooper Company. Of this company, F. L. Fairchild was president, C. G. Cooper, secretary, and D. B. Kirk, treasurer. B. B. Williams, now president of the Cooper-Bessemer Corporation, was assistant secretary of the company working with C. G. Cooper, then secretary. Mr. Cooper, a son of Elias, became president of the company in 1912 upon the death of Mr. Fairchild.

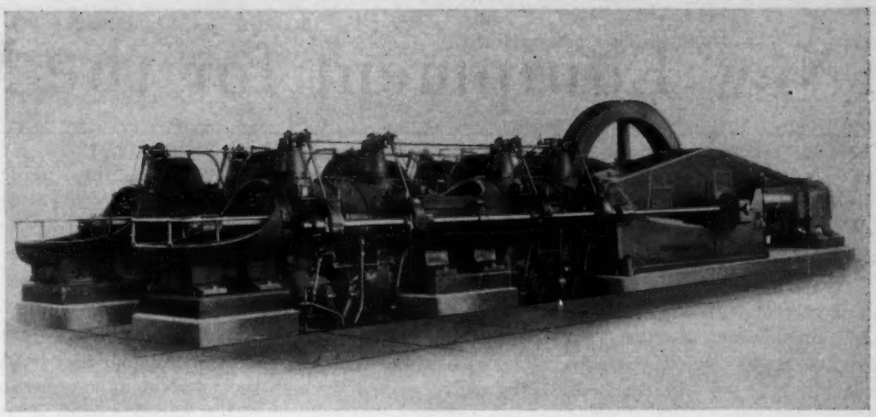
With the turn of the century The C. & G. Cooper Company was widely known as builders of high-powered steam engines and at that time it be-

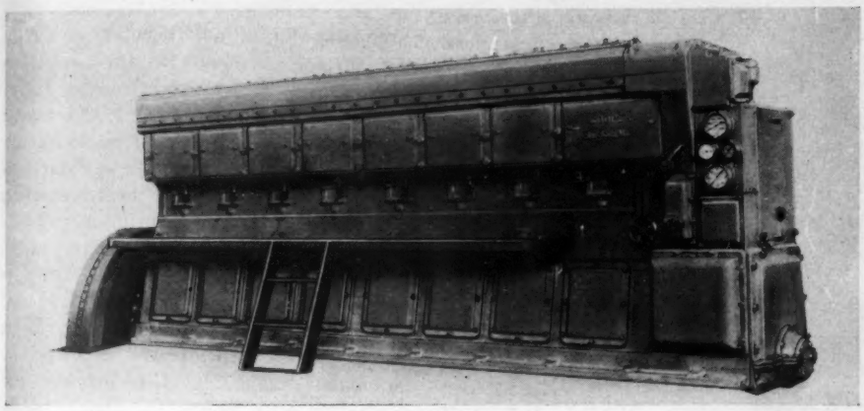


Cupola for Making Iron Castings—Beginning of the Cooper-Bessemer Corporation

gan to turn to the relatively new and rapidly expanding petroleum and natural gas industries. Across the border, in the state of Pennsylvania, the founders of Bessemer Gas Engine Company were starting to supply clutches for engines in the oil fields and the two companies began to grow and expand along similar lines.

Both concerns realized the importance of natural gas and its commercial value, and both recognized the increasing utilization of petroleum and its chief product, gasoline. The C. & G. Cooper Company amazed the world of machinery in 1908 by designing and building a single gas engine of 1000 horsepower. It was also instrumental in designing the great compressors used on natural gas pipe lines and contributed to the successful extraction or production of more crude from deep wells by supplying economical power units that operated on raw natural fuels.





Above—Cooper-Bessemer 1500 horsepower Compressor. At left—Industrial Diesel Made By This Company

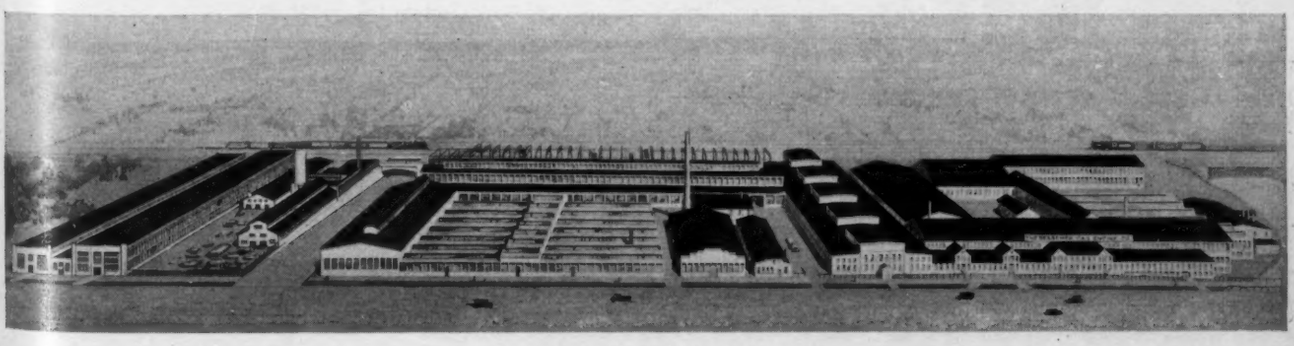
The two companies prospered through the following decades. The Bessemer Gas Engine Company was capitalized at $3,000,000 in 1923 and had grown to such size that it occupied 29 buildings. The C. & G. Cooper Company recognized the Diesel engine in 1925 and secured manufacturing licenses for the German MAN design. The two companies had so paralleled their activities in 1929 that the C. & G. Cooper Company purchased Bessemer Gas Engine Company and the present The Cooper-Bessemer Corporation was organized.

In the organization's 100 years some of the world's outstanding power units have been designed and built. Particularly in the past decade it has supplied the biggest engines in the country for powering private yachts.

In the petroleum industry several of the principle natural gas lines stretching half across the continent utilize batteries of compressors and gas engines. In the refineries the Diesels are found in electricity generating plants, gas engine driven compressors are utilized in the gasoline recovery systems, and fuel gas systems. In the oil fields, batteries of the gas engine driven compressors are engaged in air-gas lift and repressuring work, and for gathering natural gas for boosting through absorption and compression gasoline extraction plants. The Diesels are used by pipe line companies in their pump stations.

Within the past two years the proration agreements in the oil industry and the standstill condition of the American shipyards, have reduced the corporation's business to a relatively low percentage of its capacity. Yet, the latest report of B. B. Williams, president, shows that the company was flexible enough to enhance its cash position steadily since 1930.

And with the much talked of depression still prevailing Cooper-Bessemer engineers, technologists and executives continue to study the needs, both indicated and actual, of the industries they serve, and in well equipped chemical and physical laboratories continue the progressive development work necessary to meet more severe demands made by present day machinery and the machinery of the future. One of the oldest builders of oil and gas engines in the United States, this year celebrating its centenary, is carrying on the work begun 100 years ago by Charles and Elias Cooper. The horse that sold for $50, and the "fifty" that went into the first cupola, laid the foundation for a business now valued at $8,000,000.



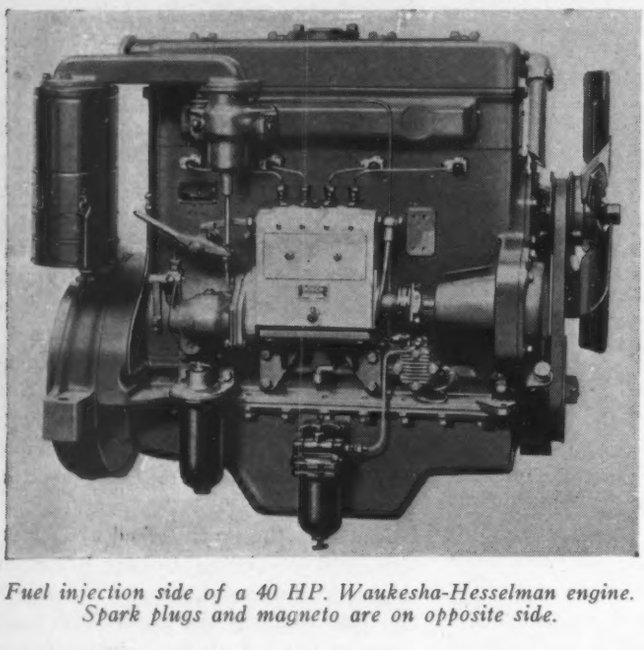
The Cooper-Bessemer Corporation Plant at Grove City, Pennsylvania

New Equipment for the Modern Plant

1. Oil Engine

WAUKESHA MOTOR COMPANY

Waukesha Motor Company, Waukesha, Wisconsin, has just concluded license arrangements with the Hesselman Company of Stockholm, Sweden, for American rights under the Hesselman oil engine patents. Under these patents, they will manufacture a line of heavy oil engines for truck, tractor, and general industrial service.



Fuel injection side of a 40 HP. Waukesha-Hesselman engine. Spark plugs and magneto are on opposite side.

Hesselman engines occupy a place midway between the automotive Diesel engine and the gasoline engine. They burn the same fuels as a Diesel engine, but use electric ignition. They show slightly less fuel economy, but they weigh less.

The Hesselman cycle is of different principle from previous heavy fuel oil engine cycles. On the intake stroke, the cylinder is filled with air only. A specially designed intake valve directs the air and imparts to it a rotary movement in the cylinder. The air is compressed to a greater degree than in a gasoline engine, but not to the same extent as in a Diesel. At the top of the compression stroke, a high pressure Bosch injection pump delivers a quantity of heavy fuel, the correct amount to insure complete combustion being controlled by mechanical linkage with the air throttle. The fuel is injected through special Hesselman injectors which throw it into the rotating air stream where the fuel mist is intimately mixed with the air. At this moment the spark plug fires the fuel mixture. At the end of the power stroke, the exhaust valve opens and releases the burned mixture, and the cycle is repeated.

The Waukesha people claim that Hesselman engines will burn any fuel that a Diesel will handle, and some fuels that a Diesel engine cannot utilize, and that they can handle any common commercial fuel oils, being limited only by one condition—viscosity—they must flow readily through the injection system at the surroundnig operating temperatures. Mixtures of alcohol and gasoline can be used without any change in the engine's adjustments, and with minor changes to the air intake system, natural gas can be burned with equal satisfaction.

The manufacturer states a 40 horsepower Hesselman can show an economy of .53 pounds fuel per brake horsepower hour—the equivalent of about 14 horsepower hours per gallon.

2. Wide Range Oil Burner

THE BABCOCK & WILCOX CO.

The Babcock & Wilcox Company, 85 Liberty Street, New York, New York, announces development of an oil burner that can be quickly adjusted to operate efficiently over a wide range of capacities.

The barrel assembly of the burner, which is known as the B & W wide-range mechanical atomizing oil burner, is used in the standard B & W mechanical-atomizing oil burner register or as the oil burning element of the multifuels burner.

The fuel oil is delivered to the burner tip through two passages, an outer annular passage carrying the primary oil stream and the center oil barrel carrying the secondary oil. Both primary and secondary oil meet at one nozzle, and a sprayer plate at the burner tip. Changes in capacity with a given nozzle and sprayer plate are secured by operating at low capacities with primary oil alone, and at higher capacities with primary and secondary oil together. A capacity variation of four to one with any one combination of a sprayer plate and its nozzle may be secured.

3. Indicating Flow Meter

THE FOXBORO COMPANY

The Foxboro Company, Foxboro, Massachusetts, announces a new indicating flow meter for accurately and inexpensively securing readings of flow. The instrument gives positive check on operating conditions and aids the operator

Foxboro Flow Meter

— — — — — — — — *MAIL COUPON* — — — — — — — —

REFINER AND NATURAL GASOLINE MANUFACTURER,
Houston, Texas, U. S. A.

Please see that I am supplied, without obligation, additional information on New Equipment Items Nos. .....described in July, 1933, issue of REFINER.

Name .....

Company .....

Address .....

in obtaining closer regulation. The standard scale reads in per cent of total flow. Beneath the graduated scale is a white space on which reference notations of the actual flow may be marked. These notations are used by the operator when regulating the flow. If desired, the instrument may be equipped with a scale that gives direct readings of flow.

4. Glyptal Cloth

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, announces production of Glyptal cloth, impregnated with a compound of synthetic resin produced from phthalic anhydride and glycerine.

According to the manufacturer, the cloth, used primarily as an insulator for cable, in hot oil, or its derivatives for years without showing signs of deterioration. The new insulation is flexible and tough.

5. Packing Ring

YARNALL-WARING COMPANY

Yarnall-Waring Company, Chestnut Hill, Philadelphia, Pennsylvania, announces a new laminated packing ring for high steam pressures to be used in connection with a seatless blowoff valve. The manufacturer claims the new ring to be a distinct improvement in design and material over the previous model.

6. Automatic Lime Slaker

THE HADEN LIME COMPANY

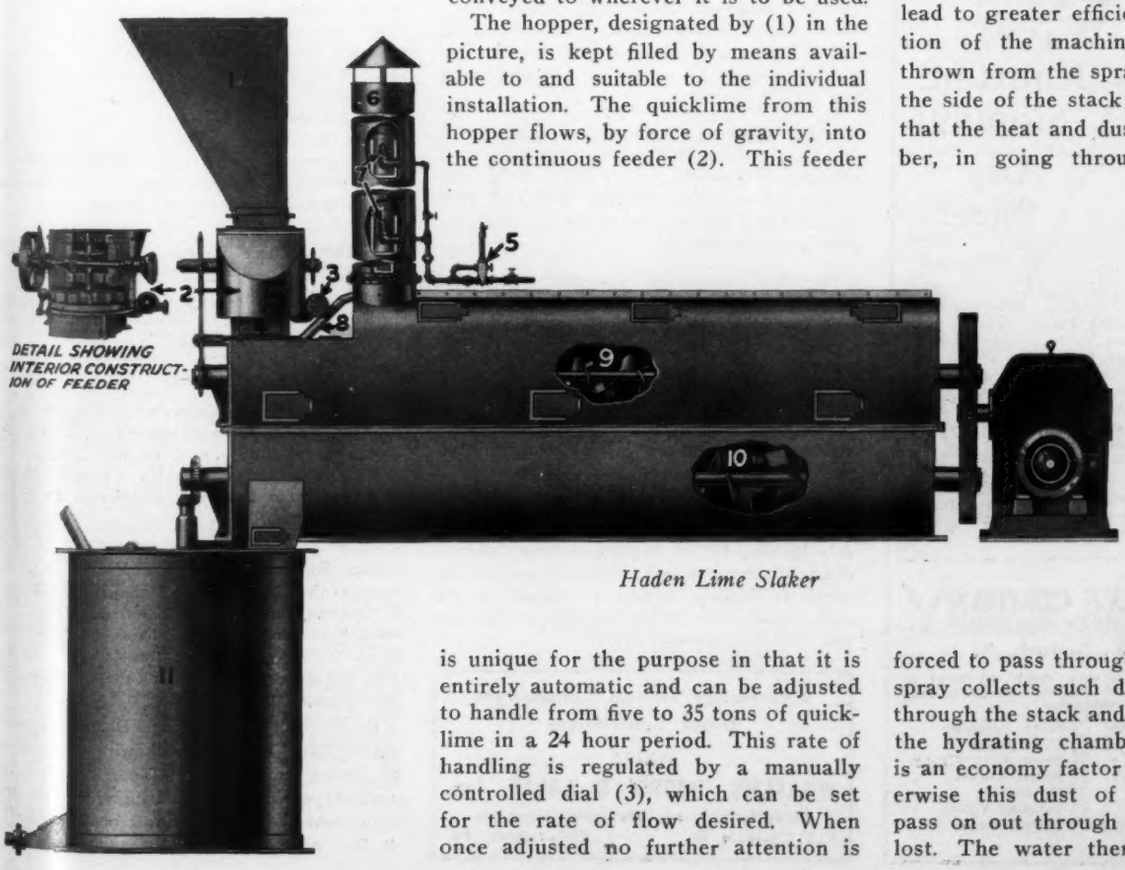
The Haden Lime Company, Houston, has introduced the Pioneer Continuous Lime Slaker, for hydrating quicklime, especially applicable to oil refining. The machine will assist materially in the reduction of costs and the simplification of the slaking process.

This economy is evidenced by the fact that the installation of the machines permits the refinery to purchase straight quicklime in bulk rather than hydrated lime. This represents a considerable saving as the quicklime is less expensive than the hydrated. Again it is well known that hydrated lime is approximately 25 per cent moisture and naturally the purchase of quicklime instead of hydrated lime would effect a saving in the amount of hydrated lime secured against the amount in weight of quicklime run through the machine.

The machine is entirely automatic and completely eliminates any hand labor for operation. No attention is required except for regulation when a change in production is desired. It has a capacity of from 5 to 35 tons per 24 hours. The quicklime can be unloaded from cars direct to a storage hopper or to the machine and the hydrated product from the machine can then be converted immediately into milk-of-lime or oil-and-lime slurry or can be conveyed to wherever it is to be used.

The hopper, designated by (1) in the picture, is kept filled by means available to and suitable to the individual installation. The quicklime from this hopper flows, by force of gravity, into the continuous feeder (2). This feeder is unique for the purpose in that it is entirely automatic and can be adjusted to handle from five to 35 tons of quicklime in a 24 hour period. This rate of handling is regulated by a manually controlled dial (3), which can be set for the rate of flow desired. When once adjusted no further attention is required until it is desired to increase or decrease the production. To determine the correct amount to be fed, it is necessary to remove from an inspection hole (4), provided for the purpose directly under the feeder ejection plate, the entire quantity of quicklime expelled by one section of the feeder. This sample is then weighed and the correct setting of the manual dial is determined.

The quicklime then drops from the feeder into the upper hydrating chamber where it unites with water for the purpose of hydration. As is known by those who are now hydrating quicklime in some manner, the amount of water that is added to the quicklime is a vital factor in the results obtained. To assure the users of the Pioneer Continuous Lime Slaker the proper results, a Vaughn flowmeter (5), for the regulation of the water supply, has been added. This flowmeter is set by hand according to the amount of quicklime which is allowed to go through the feeder. Once it is set to coordinate with the feeder no further attention is required, until a change in production is desired. The water from this flowmeter passes into pipes leading to the inside of the stack (6) where spray nozzles (7) are provided. This stack is located on the machine at the point where the heat from the hydrating action is the more intense and where the more rapid exhaustion of this heat will lead to greater efficiency in the operation of the machine. The water is thrown from the spray nozzles against the side of the stack in such a manner that the heat and dust from the chamber, in going through the stack, is forced to pass through the spray. The spray collects such dust as may come through the stack and carries it back to the hydrating chamber. This feature is an economy factor in itself, for otherwise this dust of quicklime would pass on out through the stack and be lost. The water then runs down the



Haden Lime Slaker

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Clip this to your letterhead, check the items in which you are interested, and we will gladly send prices and data. No obligation.

- ☐ The Campbell Boiler Feed Water Regulator
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- ☐ Exhaust Control System
- ☐ Temperature Regulators
- ☐ Pump Governors
- ☐ Float Valves
- ☐ Swing Joint Fittings
- ☐ Bronze Unions
- ☐ Thermostats
- ☐ Balanced Valves
- ☐ Control Valves

side of the stack where it is trapped and allowed to pass into the hydrating chamber through bypass (8), where it unites with the quicklime coming from the feeder, and the hydrating action begins. A screw-flight (9), then conveys the hydrating lime through the upper chamber where upon reaching the end it drops into the lower chamber in a powder form. Another screw-flight (10) then carries it back and allows it to drop into the agitator tank (11). Both of these screw-flights serve to agitate the lime and thereby produce thorough hydration and a more uniform product.

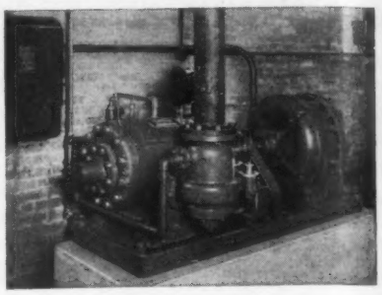
The agitator tank shown in the picture is not a necessary part of the machine. It is shown as a medium for the mixing of milk-of-lime or oil-and-lime slurry. The hydrated lime as it comes from the lower chamber can be removed in any manner desired by the individual user to any point of usage.

Power is supplied from a 10 horsepower motor through a Jones Worm-Gear reducer box. Thus, extremely low power consumption is added to negligible labor costs in the operation of the equipment.

1. Air Compressor

ALLIS-CHALMERS MANUFACTURING COMPANY

Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, announces a complete new line of single-stage, water-cooled, rotary air compressors ranging in volume from 50 cubic feet per minute to 2000 cubic feet per minute, at pressures up to 150 pounds and vacuums up to 29.85 inches mercury.



Allis-Chalmers Compressor

No belts or pulley as normally required, as the units operate at standard motor speeds. The design is simple, involving no valves or complicated motions. All working parts are enclosed, but easily accessible.

Items About Manufacturers

The Bristol Company, Waterbury Connecticut, has established New York offices in the Daily News Building, 220 East 42nd Street. C. W. Williamson, district manager, continues in charge, assisted by a staff of six application and service engineers.

Wyatt Metal & Boiler Works announced a three per cent dividend on its $1,000,000 capital stock at a meeting of the board of directors at the offices of the company in Dallas, June 14. Dividend will be paid in two installments, July 1 and October 1.

Northern Equipment Company, Erie, Pa., announces appointment of C. H. Wilson, 1403 Park Avenue, Troy, N. Y., as sales representative in the Albany district.

The Babcock & Wilcox Tube Company, announces that L. E. Jeaneret, special representative, is acting temporarily as district sales manager of the company's Detroit territory, replacing J. E. Polhemus, former manager.

Shand and Jurs Sales Company announces removal of its New York offices from the Lincoln building to 225 Madison Avenue. At the same time the company announces appointment of M. J. Vierling as district manager for Detroit, Michigan, with headquarters in the General Motors building.

Electrically Driven Centrifuges
Hand Centrifuges
WRITE
WILLIAMS, BROWN & EARLE, Inc.
Manufacturers of Laboratory Apparatus
918 Chestnut St. Philadelphia, Pa.

Kerotest Manufacturing Company, Pittsburgh, announces the appointment of J. D. "Eb" Isaacks to its sales staff, effective June 15. For the past seven years "Eb" has been research engineer for Gulf Publishing Company and associated papers. He will make Houston his headquarters and will cover the active territories in connection with the sale of completely assembled and tested "Gray-Kerotest" Christmas Trees, etc., as well as the regular line of Kerotest valves and fittings.

Bethlehem Steel Company, Bethlehem, Pennsylvania, will open a district sales office at Houston, Texas, on July 1, with J. E. Moore as district manager of sales. The offices will be in the Petroleum Building, Texas Avenue and Austin Street.

Bethlehem Steel Company, Bethlehem Pennsylvania, announces appointment of William A. Gayou as resident agent of the company at Kansas City, Missouri. He succeeds P. E. Anderson, who has been transferred to Houston.

The Ruberoid Company, New York, announces that Marshall L. Stirling of R. B. Hall & Company of Dallas, national sales agents of the oil, gas and industrial division of The Ruberoid Company, has been transferred to Houston, where he will maintain Gulf Coast district headquarters.

R. B. Hall & Company, Dallas, announce that William H. Boyer will, with headquarters at Dallas, contact East Texas consumers of products of The Ruberoid Company of New York, which organization is represented by R. B. Hall & Company.

CATALOGS . . . BULLETINS

Helpful Publications Which Manufacturers Will Be Glad to Send Free for the Asking

Portable Ventilator

Coppus Engineering Corporation, Worcester, Massachusetts, has just issued Bulletin 166 describing the new portable gasóline engine driven cable manhole ventilator for ventilating and driving noxious fumes from confined working places.

Engine Cylinder Pressure Indicator

Bacharach Industrial Instrument Company, 7000 Bennett Street, Pittsburgh, Pennsylvania, announces availability of an illustrated bulletin describing Maihak Type 2-CP engine cylinder pressure indicator designed particularly for portability and use in the field. The bulletin is No. 263.

Indicating Controllers

Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., has prepared a bulletin giving detailed information regarding indicating temperature controllers designed to indicate and control temperature of air, gases, oil and other liquids in ducts, tanks, vats, pipes, etc. They are self contained controllers actuating electric contacts which govern the mechanisms of heat supply, pumps, or fan cperation, etc.

Liquid Transfer

Roots - Connersville-Wilbraham, Connersville, Ind., in Bulletin 21-B24, gives detailed information on rapid and sanitary transfer of liquids by positive air pressure.

Motors

General Electric Company, Schenectady, N. Y., is distributing bulletins on explosion proof motors and control for hazardous locations, quiet induction motors, and sound-isolating motor bases.

Orifice Meters

American Meter Company, Erie, Pa., has prepared catalog Eg-2, 16 pages, giving detailed data regarding Westcott orifice meters for measurement of gas, oil, air, steam and fluids.

Packing Rings

Yarnell Waring Company, Philadelphia, has literature dealing with its newly developed packing rings for high steam pressures. Ring consists of several stainless steel rings with long fiber asbestos packing between them.

Temperature Regulator

Atlas Valve Company, Newark, N. J., is distributing a 12-page pamphlet describing a new and accurate regulator for maintaining temperature of water or other liquids in all types of open or closed tanks or heaters. Engineering information included.

Burners

Lee B. Mettler Company, 406 South Main Street, Los Angeles, has prepared a new highly illustrated 32-page catalog discussing its line of gas burners and their application in many industrial fields.

Welding

The Linde Air Products Company, 30 East 42nd Street, New York, is distributing an interesting and valuable 16-page booklet "Oxwelding for General Maintenance," describing use of oxy-acetylene process for welding and cutting in reclamation of broken and worn machine parts, alteration, fabrication and installation of equipment. Included is a chart giving 13 simple tests for identifying the more common metals.

Wire Cloth

International Nickel Company, Inc., 67 Wall Street, New York, is distributing a new booklet dealing with Monel Metal and Nickel Wire Cloth for use in filtration work.

Pumps

Goulds Pumps, Inc., Seneca Falls, N. Y., is distributing Bulletin No. 203, describing its Flexi-Unit Centrifugal Pumps, capacities to 4500 g.p.m., heads up to 350 feet. Well illustrated and including several pump selection charts.

Flue Gas Analyzers

The Hays Corporation, Michigan City, Ind., is distributing Catalog TSE 33, describing Hays Flue Gas Analyzers and portable combustion test sets. The company also is mailing to those interested an engineering discussion "Handling the Orsat" (Gas Analyzer), which is numbered Bulletin No. 2006.

Heat Exchangers

Westinghouse Electric and Manufacturing Company is distributing Bulletin 1924 describing the design and construction features of Westinghouse Heat Exchangers. A number of construction features have been perfected which contribute to low installation cost, reduced maintenance, ease of cleaning and reliability.

Control Valves.

Frick Company, Inc., Waynesboro, Pa., has ready for distribution Bulletin No. 203-A describing its complete line of electric control valves for refrigeration plants. Includes illustrations and data on various types of valves and their installation.

Metallizing

International Metallizing Association, 214 Provost Street, Jersey City, N. J., is distributing a complete engineering discussion of the metallizing process, its applications, advantages and accessory equipment.

Gaskets

Goetze Gasket and Packing Company, New Brunswick, N. J., is distributing a new folder describing in complete detail its line of gaskets and packings for all purposes.

Turbines

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., is distributing an illustrated 12 page bulletin "Condensing Bleeder Turbines" describing its latest developments in turbine construction.

Electrode

Metal & Thermit Corporation announces two additions to the Murex line of heavy mineral coated arc welding electrodes. One is a special electrode designed for welding Cromansil Steel, a new development in high strength steels having a tensile strength of 80,000 to 100,000 pounds per square inch along with high ductility. The new electrode gives a deposit of the same analysis as Cromansil. The weld metal has physical properties which are equal to the parent metal in every respect.

The second addition to the Murex line is an electrode which deposits a metal containing 4 per cent to 6 per cent Chrome and .5 per cent Molybdenum. It is specially suited to the welding of petroleum refinery equipment where metal of this type is used extensively.

Regulator

Morey & Jones, Ltd., 922 South Hemlock Street, Los Angeles, is distributing Bulletin No. 210, descriptive of its MJL Regulator for Combustion Control, including all engineering information pertaining to the device.

Distillation Equipment

J. P. Devine Manufacturing Company, Mt. Vernon, Illinois, is distributing an attractive, well illustrated catalog dealing with the company's facilities for producing distillation equipment, riveted or welded pressure vessels, machined castings and forgings, fractionating towers, heat transfer equipment, atmospheric single or multi-stage tube stills, recovery plants, treating plants, and other refining equipment.

Ignition Arch

Semet-Solvay Engineering Corporation, 40 Rector Street, New York, is distributing bulletin 46, describing its new ignition arch process for carbureting with heavy oil in the enrichment of water gas, including a novel model of the carburetor.

USE THIS COUPON

(Address this manufacturer direct)

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Please send me, without obligation, free booklet described in the July, 1933, issue of REFINER AND NATURAL GASOLINE MANUFACTURER.

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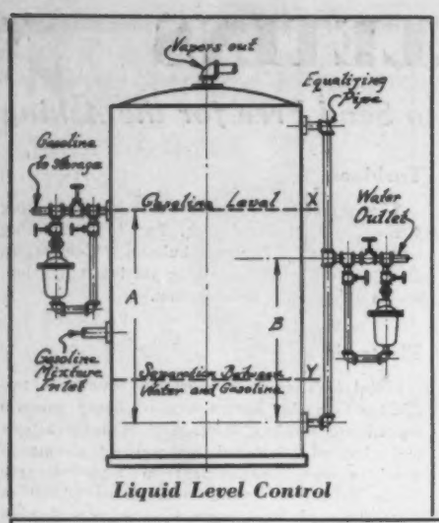


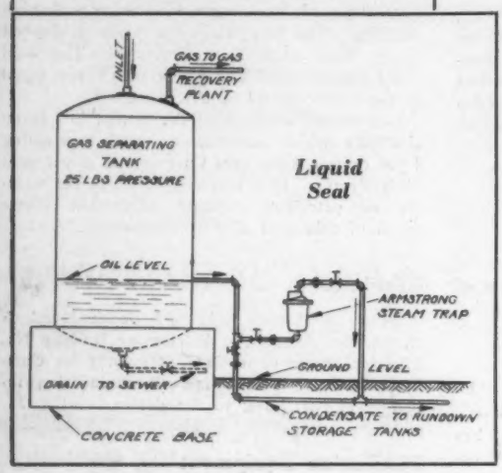
Liquid Level Control

Armstrong Traps for Many Uses in the Oil Industry

THERE are more Armstrong *Steam* Traps in service in oil refineries than any other mechanically operated trap. In addition there are a lot of Armstrong Traps used in refineries and natural gasoline plants which have no connection with steam. Maintaining liquid level control or a liquid seal and draining compressed air lines and air equipment are among the most common non-steam applications.

The inverted bucket principle was originated by Armstrong and this organization has over 20 years experience in applying traps of this type to meet the varied problems in trapping air, water, oil, gas and steam. Armstrong Traps are available for any pressure, any volume of discharge, any amount of air, and to handle any corrosive substances.

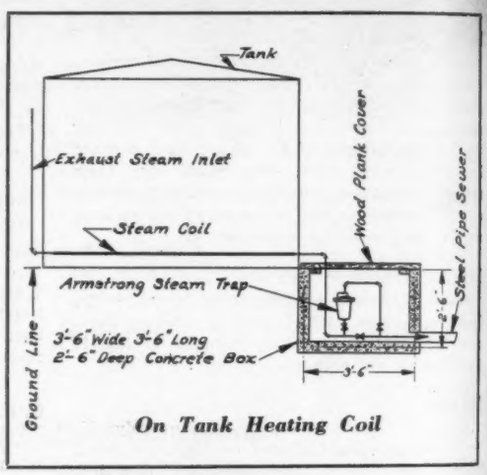
Local representatives are at your service to counsel on the selection, application and operation of traps. The Armstrong Steam Trap Book contains valuable data on all phases of trapping. It is free. Request your copy.



Liquid Seal

Armstrong Machine Works

Three Rivers, Mich.



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